ONE HUNDRED AND FIFTIETH ANNIVERSARY

OF THE FOUNDATION OF THE

AMERICAN PHILOSOPHICAL SOCIETY.

MONDAY, May 22, 1893, 8 P.M.

The Society was called to order by the President, Hon. Frederick Fraley, LL.D., who delivered the following address of welcome:

United Brethren (for so I think I can appropriately address you), it gives me great pleasure to welcome this goodly company which has come to us from abroad to the State of Pennsylvania and the city of Philadelphia, and to the ancient edifice in which we are now assembled.

I esteem it the crowning glory of a long life to be permitted to look upon this day. I have been a sojourner on earth for nearly ninety years, and I have looked upon this goodly world for the last seventy-five years with a full appreciation of what it contains and how much good it is possessed of to benefit mankind. Among those benefits I recognize the existence of our scientific institutions, which have gradually grown to be numerous in our territory, to be the correspondents of the older institutions abroad; and to have the opportunities occasionally of mingling in such assemblies as this for the promotion of the common objects they have at heart, for the general promotion of useful knowledge.

I hope that the occasion in which we have come to take part will be blessed, as our previous celebrations have been, with a unity of purpose, with the beginning of friendships that shall endure through life, with stimulus for the creation of new institutions of similar

character, so that, as the years roll on, the circle of science will be completed and extended, and the benefits arising from a diffusion oı useful knowledge will become more and more a blessing to the world at large.

It is difficult for me to find words with which I can pour out the fullness of my heart to you, my brethren, who are here around me, and I trust from the greetings which I have witnessed this evening, in the gratulations and friendships which have saluted my ears, that this occasion will be memorable in the history of our scientific life; and that if we have the advantages which seem to me to be promised to us from this gathering, when we shall separate at the close of the week there will be not only a union of hearts and a union of hands, but a union of common purposes and pursuits. Our country is so large, our population is so great, our resources of all kinds are so abundant, that everything which can stimulate the human intellect to labor, for the increase of knowledge and for the increase of happiness, lies all around us.

While you are here you will, I hope, accept and participate in those social enjoyments that will be tendered to you outside of the mere exercises of our meeting, and that you will visit our ancient University, the Girard College for orphans, the Drexel Institute, the United States Mint at Philadelphia, and, among others, those two hives of industry which bear testimony to the great improvements in the extension and perfection of steam machinery, in its application to naval purposes and to land transportation, the workshops of the Cramps and the "Baldwin's."

These opportunities are freely tendered to you, and our Committee of Arrangements will divide themselves into squads and take charge of you, so far as your individual preferences may choose, for visiting these different institutions.

Again renewing the cordial welcome that I have given you, I bid you now, gentlemen, Godspeed in the enterprises in which you may engage for the coming three days of this week, so that when the time comes for drawing upon us the curtain of separation, we will disperse with the conviction that we have added to our knowledge and to our friendships, and that we have done something for the benefit of our country and for the world at large.

It will be a great gratification to me personally, and I know that it will gratify our friends who are here assembled, if some of our

guests will say a few words of congratulation to us, I may ask, and also give the views that they may take of such a celebration as we propose to hold.

Mayor Stuart, having been introduced by President Fraley, addressed the Society, as follows:

Mr. President, Guests and Members of the American Philosophical Society:—I had no idea when I came into the room to-night that I was to say anything in the way of welcoming the guests of this Society to Philadelphia. My good friend, Mr. Fraley, whom every Philadelphian loves and respects, has said far more to you in the few moments he has spoken than I could say if I were to speak for half an hour; but I have been requested, on behalf of the Committee, to say a few words of welcome to the distinguished guests who have honored our city to-day and this week by their presence, and in the name of the people of Philadelphia, who cherish the highest regard and respect for this ancient and useful Society, I extend to you a most heartfelt welcome, hoping that your visit among us will be as pleasant and agreeable to you all as I know your presence will be to us.

President Fraley next introduced Hon. Louis Vossion, Consul of France at Philadelphia, who presented the greetings of the University of Paris to the Society, as follows:

A La Société de Philsophie de Philadelphie—L'Université de Paris.

Messieurs:—L'Université de Paris est heureuse de saluer votre Société qui cultive, avec tant de succès, les Sciences philosophiques dans un pays que l'Europe considère trop souvent comme exclusivement occupé d'affaires industrielles et commerciales.

Il appartenait à l'État qui a compté parmi ses citoyens un philosophe pratique tel que Franklin de tenir haut et ferme le drapeau de la philosophie dans les États-Unis d'Amérique.

La France n'oublie pas que la Pensylvanie lui a envoyé ce grand patriote qui a noué entre votre jeune nation et la vieille France des relations d'affection et que c'est aux environs de Philadelphie que

La Fayette a scellé de son sang, dès sa première bataille, cette amitié impérissable.

Nous aimons aussi à nous rappeler que Franklin n'a pas seulement acquis à son pays les sympathies de la France, mais que par la dignité simple de sa vie, par ses paroles et par ses écrits, il nous a préparés à la liberté en nous montrant qu' une grande nation peut se gouverner elle-même.

Ces souvenirs ineffaçables vous assurent, Messieurs, de la sincérité des vœux que nous formons pour votre Société et pour la Grande République des États-Unis d'Amérique.

Le Recteur, Président du Conseil général,
EREUD.

Le Secrétaire,
ERNEST LAVISSE.

Prof. William B. Scott was next introduced, who, on behalf of the University of Princeton, New Jersey, read the following address:

SOCIETATI PHILOSOPHIÆ AMERICANÆ UNIVERSITAS PRINCETONIENSIS.
S. P. D.

Cum hoc quidem semper decet eos qui scientias liberales amore, labore honore illustrauerint liberali in grata memoria haberi, sic enim debita immortalitas his rite tribuitur qui scientiam uiuificauerunt, tum in præsenti præcipue conuenit nos Præsidem et Professores Universitatis Princetoniensis lætos celebrare uobiscum sæculares ferias mox Philadelphiæ habendas atque hunc annum centesimum quinquagesimum Societatis Philosophiæ Americanæ conditæ commemoraturas.

Itaque nobis placuit inuitatui uestro amicissimo respondentibus Guilielmum Berryman Scott, qui apud nos Geologiam Palæontologiamque profitetur, diligere uicarium, cui insuper mandaruimus ut ipse pro nobis gratias et gratulationes coram reddat.

Datum PRINCETONIÆ a. d. xiii Kal iun. [SEAL.]
Anno Salutis MDCCCXCIII.

The following address from the Naturwissenschaftliche Verein in Kiel was read:

DER AMERIKANISCHEN PHILOSOPHISCHEN GESELLSCHAFT ZU PHILADELPHIA ZU IHREM HUNDERTFÜNFZIG-JÄHRIGEN STIFTUNGSFESTE AM 22 MAI, 1893, GEWIDMET VOM NATURWISSENSCHAFTLICHEN VEREIN IN KIEL.

Ist unser Verein auch durch die räumliche Entfernung gehindert Ihrer Einladung gemäss einen Abgeordneten zu Ihrer Festfeier zu senden, so sind wir doch nicht verhindert, Ihnen unsere Grüsse und Wünsche über das Meer hin zu schicken.

Ihre Gesellschaft, so viel wir wissen eine Vereinigung mit der von Franklin begründeten Gesellschaft Junto, feiert fast genau zu gleicher Zeit wie eine der ältesten deutschen naturwissenschaftlichen Gesellschaften, diejenige zu Danzig, das hundertfünfzig-jährige Stiftungsfest.

In zahlreichen Bänden reichen Inhaltes haben diese beiden Gesellschaften die Naturforschung gefördert und der Verbreitung nützlicher Kenntnisse zum Besten der Menschheit gedient.

Fast zahllose Gesellschaften sind seitdem Ihrem Vorbilde gefolgt; Sie aber können Sich rühmen unser naturwissenschaftliches Zeitalter vorbereitet zu haben.

Wir senden Ihnen unsere besten Wünsche für das fernere Blühen und Gedeihen Ihrer Gesellschaft.

DER NATURWISSENSCHAFTLICHE VEREIN IN KIEL.
DR. G. KARSTEN, C. REINBOLD, L. WEBER.

Provost William Pepper being next introduced, presented on behalf of the University of Pennsylvania the following address:

SOCIETATI PHILOSOPHICÆ AMERICANÆ UNIVERSITAS PENNSYLVANIENSIS. S. P. D.

Magno cum gaudio litteris vestris nuper acceptis intelleximus appropinquare diem natalem Societatis Vestræ abhinc annos centum et quinquagenta conditæ; ad quem diem maxima lætitia concelebrandum nos non solum humanitas Vestra in convocando, sed etiam vel maxime id movet, quod Societatem et Universitatem meminimus ab uno conditore eodem fere tempore institutas, omnibus enim notum inter conditas eas annos intercessisse decem vel haud multo plures. His igitur jam Vobis conjunctos vinculis, tempore, quod

et maximum, Franklinio conditore nunc cum maxime juvat illius hominis, decoris nostra communis, merita commemorare erga nos, civitatem nostram immo patriam universam, necnon operam egregie navatam in litteris scientiaque promovendis. Is enim est ille vir, cui inter nostrates pæne soli hoc contigerit, nullum opus in nostra urbe, quod ad bonum publicum spectet, non tetegisse, nullum, quod tetigerit, non auxisse, dignumque esse qui hanc laudem audiat, meliora sevisse quam speraverit vel etiam somniarit. Omnia quæ instituit ille, Bibliotheca Philadelphica, Valetudinarium Pennsylvaniense, Universitas Pennsylvaniensis, hodie, quod ad magnitudinem pertinet, adeo sunt aucta, quod ad utilitatem publicam, tantum ab inittiis illis parvis, ut nobis nunc videtur parumque sunt provecta quantum nemo, ne in somnio quidem fieri posse imaginaretur.

Nec solum habemus illum, cujus hodie mentionem debeamus facere: immo quam multi philosophi illustrissimi, Societatis socii, magna pars fuerunt rerum a Universitate prospere gestarum! Quis enim est civis noster quem dies hic faustus felix ad commemoranda non ipse ducat nomina hæc clarissima; Franklin, Bond, Bartram, Hopkinson, Coleman, Alison, inter fundatores venerabiles Vestros; —Rittenhouse, Smith, Ewing, Adrian, Morgan, Kuhn, Redman, Kinnersley, Barton, Coxe, Hare, Patterson, Rush, Wistar, Bache, Hornor, Wood, Price, Leidy, olim socii illustri Vestri, Curatores, Professoresque Universitatis nostræ honoratissimi! Et in præsenti eadem communitas atque necessitudo nos feliciter conjungit. Vobis igitur gloriam per annos centum et quinquagenta conservatam et auctam sincere gratulamus, optamusque ut illa in omnem posteritam vigeat ac floreat. Valete!

GUILELMUS PEPPER,
Præfectus.

Curatorum a secretis,
JESSE Y. BURK.

[SEAL.] WILLIAM PEPPER, M.D., LL.D.

Mr. Price, on behalf of the Committee, then read a number of telegrams received by the Society from various scientific societies.

ST. PETERSBURG, May 20, 1893.

TO THE AMERICAN PHILOSOPHICAL SOCIETY, PHILADELPHIA:

Russisches Geologisches Comité sendet seine beste Glückwünsche

am bedeutungsvollen Tage Hundertfünfzig-jährigen Jubiläums der Gesellschaft. KARPINSKI.

MOSCOW, May 22, 1893.

TO THE AMERICAN PHILOSOPHICAL SOCIETY, PHILADELPHIA:

The Imperial Society of Friends of Natural Sciences, Anthropology and Ethnography, Moscow, congratulate cordially upon the great Anniversary, and send the best wishes for the future.

President, ANOUTCHIN.

Secretary, GONDATTI.

MOSCOW, May 21, 1893.

TO THE AMERICAN PHILOSOPHICAL SOCIETY, PHILADELPHIA:

Société Imperiale Naturalist, Moscow, presente felicitations a Société Philosoph occasion 150 Annivers de fondation.

President, SLOUDSKY.

ST. PETERSBURG, May 21, 1893.

TO THE AMERICAN PHILOSOPHICAL SOCIETY, PHILADELPHIA:

Imperial Russian Mineralogical Society congratulate Philosophical Society on 150 years of existence.

Director, JEREMEJEW.

Secretair, TSCHERNYSCHEW.

HELSINGFORS, May 22, 1893.

TO THE AMERICAN PHILOSOPHICAL SOCIETY, PHILADELPHIA:

Geographic Society of Finland and Societas pro Fauna et Flora Fennica beg to present their respects and congratulations on the memorable day. BERGBOM PALMEN.

The following list contains the names of the delegates appointed to represent the various societies and institutions responding to the Society's invitation:

Société Entomologique de Belgique, BRUXELLES, BELGIUM:
    Capt. Casey, U.S.A., New York.
I. R. Accademia degli Agiati, ROVERETO, TYROL:
    Henry Phillips, Jr., Philadelphia.
K. K. Military and Geographical Institute of VIENNA:
    Capt. Karl Chevalier Rousseau d'Happoncourt,
    Lieut. Col. Robert Daublebsky von Sterneck.
L' Université de Paris:
    Hon. Louis Vossion, Consul of France at Philadelphia.

R. Università de Bologna, BOLOGNA, ITALY
Henry Phillips, Jr., Philadelphia.

University of Pisa, PISA, ITALY :
Henry Phillips, Jr., Philadelphia.

Royal Academy of PADUA :
Prof. John James Stevenson, Ph.D., New York.

R. Istituto di Studi Superiori, FLORENCE, ITALY :
Prof. Vincenzo Botta, New York.

R. Academia de la Historia, MADRID, SPAIN :
Henry Phillips, Jr., Philadelphia.

Royal Society, LONDON, ENG.:
Capt. W. de W. Abney, R. E., C. B., K. C. B.

Royal Statistical Society, LONDON, ENG.:

Royal Institution of Great Britain, LONDON, ENG.:
Sir Douglas Galton, K. C. B.

Royal Astronomical Society, LONDON, ENG.:
Isaac Roberts, D. Sc., F. R. S., F. R. A. S., F. G. S.

Royal Asiatic Society of Great Britain and Ireland, LONDON, ENG :
Prof. Charles R. Lanman, Cambridge, Mass.

Royal Society of Edinburgh, EDINBURGH, SCOTLAND :
Prof. Herbert Anson Newton, New Haven, Conn.

Canadian Institute, TORONTO, CANADA :

Nova Scotian Institute, HALIFAX, N. S.:

Harvard University, CAMBRIDGE, MASS.:
Prof. William W. Goodwin, LL.D.

Museum of Comparative Zoölogy, CAMBRIDGE, MASS.:
Prof. George Lincoln Goodale, LL.D.

Massachusetts Historical Society, BOSTON, MASS.:
Dr. Samuel A. Green.

American Academy of Arts and Sciences, BOSTON, MASS.:
Prof. Josiah P. Cooke, LL.D.,
Prof. Alpheus Hyatt, Cambridge, Mass.

Boston Society of Natural History, BOSTON, MASS.:
Prof. Samuel H. Scudder, Ph.D.

Institute of Technology, BOSTON, MASS.:
Prof. Thomas Messinger Drown.

American Antiquarian Society, WORCESTER, MASS.:
Hon. Henry C. Lea, LL.D., Philadelphia.

Providence Franklin Society, PROVIDENCE, R. I.:
Prof. Levi W. Russell.

New Haven Colony Historical Society, NEW HAVEN, CONN.:
Prof. James M. Hoppin, D.D.

Yale University, NEW HAVEN, CONN.:
Prof. Othniel C. Marsh, LL.D.

American Chemical Society, BROOKLYN, N. Y.:
Prof. George F. Barker, M.D., Philadelphia.

Columbia College, NEW YORK:
Prof. Charles F. Chandler, Ph.D.

American Geographical Society, NEW YORK:
Prof. William Libbey.

Mathematical Society, NEW YORK:
Prof. Henry B. Fine.

Oneida Co. Historical Society, UTICA, N. Y.:
Gen. Charles W. Darling.

College of New Jersey, PRINCETON, N. J.:
Prof. William B. Scott, Ph.D.

Lafayette College, EASTON, PA.:
President Ethelbert D. Warfield, LL.D.,
Prof. Francis A. March, LL.D.

Linnean Society, LANCASTER, PA.:
Prof. H. F. Bitner, Millersville, Pa.,
Prof. J. H. Roddy, "
Prof. S. M. Sener, Lancaster, Pa.

College of Pharmacy, PHILADELPHIA:
Charles Bullock.

Academy of Natural Sciences, PHILADELPHIA:
Gen. Isaac J. Wistar.

College of Physicians, PHILADELPHIA:
Dr. I. M. DaCosta.

Numismatic and Antiquarian Society, PHILADELPHIA:
Francis Jordan, Jr.

Engineers' Club, PHILADELPHIA:
Strickland Kneass.

Wagner Free Institute, PHILADELPHIA.
Joseph Wilcox.

University of Pennsylvania, PHILADELPHIA:
Provost William Pepper, M.D., LL.D.

Franklin Institute, PHILADELPHIA:
Dr. Edwin J. Houston.

Wistar Institute of Anatomy and Biology, PHILADELPHIA:
Charles C. Harrison.

Johns Hopkins University, BALTIMORE, MD.:
Prof. Ira D. Remsen.

Maryland Historical Society, BALTIMORE, MD.:
Rev. John G. Morris, D.D.

Anthropological Society, WASHINGTON, D.C.:
Col. Garrick Mallery, U.S.A.

U. S. Coast and Geodetic Survey, WASHINGTON, D.C.:
Prof. Charles A. Schott.

Smithsonian Institution, WASHINGTON, D.C.:
Prof. Samuel P. Langley, Ph.D., LL.D.,
Dr. George Brown Goode.

Georgia Historical Society, SAVANNAH, GA.:
Henry Phillips, Jr., Philadelphia.

University of Michigan, ANN ARBOR, MICH.:
Henry Phillips, Jr., Philadelphia.

University of Indiana, BLOOMINGTON, IND.:
Prof. John M. Coulter.

Chicago Academy of Sciences, CHICAGO, ILL.:
George H. Hough, LL.D.,
Charles G. Fuller, M.D.

Societies that sent congratulations, but regretted their inability to send delegates:

Geological Survey of India, CALCUTTA.
Asiatic Society of Japan, TOKYO.
Tokyo Library, TOKYO, JAPAN.
Royal Society of New South Wales, SYDNEY.
Royal Geographical Society, BRISBANE, AUSTRALIA.
Finska Litteratur-Sällskapet, HELSINGFORS.
K. Sächsische Meteorologische Institut, CHEMNITZ, SAXONY.
K. Sächsische Alterthumsverein, DRESDEN, SAXONY.
K. Norske Frederiks Universitet, CHRISTIANIA, NORWAY.
K. Norske Videnskabers Selskab, THRONDHJEM.
Anthropologische Gesellschaft, VIENNA, AUSTRIA.
Rheinische Friedrich-Wilhelms-Universität, BONN, PRUSSIA.
Naturhistorische Verein der Preussischen Rheinlande und Westphalens, BONN, PRUSSIA.
Verein für Erdkunde, METZ, GERMANY.
Württembergische Verein für Handelsgeographie, STUTTGART, GERMANY.
Senckenbergische Naturforschende Gesellschaft, FRANKFURT A. M.
Naturwissenschaftliche Verein für Schleswig-Holstein, KIEL.
Batavian Society, ROTTERDAM.

Académie Royale des Sciences, BRUXELLES, BELGIUM.
Schweizerische Naturforschende Gesellschaft, LAUSANNE, SWITZERLAND.
Académie des Sciences, DIJON, FRANCE.
Société de Geographie, PARIS, FRANCE.
Oxford University, OXFORD, ENGLAND.
Royal Observatory, EDINBURGH, SCOTLAND.
Literary and Philosophical Society, MANCHESTER, ENGLAND.
University of California, MOUNT HAMILTON, CAL.
Ohio Archæological and Historical Society, COLUMBUS.
Georgetown College, WEST WASHINGTON, D. C.
Colorado Scientific Society, DENVER.
Elisha Mitchell Scientific Society, CHAPEL HILL, N. C.
United States Naval Institute, ANNAPOLIS, MD.
United States Military Academy, WEST POINT, N. Y.
American Museum of Natural History, NEW YORK.
University of North Carolina, CHAPEL HILL, N. C.

PHILADELPHIA, Tuesday, May 23, 1893, 11 A.M.

The Society was called to order at 11 A.M. by the President,* Mr. Fraley, who delivered the following address:

Gentlemen:—In May, 1743, when Benjamin Franklin put forth his proposals for the establishment of an American Philosophical Society in Philadelphia, he found, according to his letter, that the population of the British Colonies in North America had reached to such proportions, and the examinations that had been made of their natural resources and the industry and thrift that attended the whole population, showed that it was a favorable time for bringing the scientific men of the country into unison, and to establish a Society having for its model the Royal Society of London.

What thoughts rise in our hearts when we contemplate the boldness of such an undertaking at such a time, and how naturally we realize the fact that the struggles of the Society for existence and progress were marked with all the usual infirmities that attend upon infancy!

During the last half of the eighteenth century, Europe was agitated by bloody and cruel wars, nation waging against nation,

* At this meeting General Isaac J. Wistar appeared, and, as a newly-elected member, was presented to the President, and took his seat.

threatening the overturn of existing institutions, and ultimately culminating in the establishment of modified institutions and a gradual approach more and more to democratic organizations. Our own country, emerging from its colonial state, had made a declaration of independence; had, by great courage, trials and sufferings, accomplished finally the result of the proposition for free government; and, before the close of the eighteenth century, that Constitution of the United States under which, with a few amendments, we now so happily live and are making such mighty progress as a great nation, was adopted.

Some of the men who participated in those early struggles in our country were enrolled as members of this Society, and, among them, without an attempt to enumerate all, we find of the signers of the Declaration of Independence, Benjamin Franklin, Thomas Jefferson, Robert Morris, Benjamin Rush and several others who were early members of our organization.

In 1769, there was a union of the two Societies for the promotion of useful knowledge in Philadelphia, and Benjamin Franklin became the first President, David Rittenhouse the second and Thomas Jefferson the third. Those who followed after have fairly illustrated what were the objects which were had in view by the founders of the Society, and how they were prosecuted by the early members; and with what success the great objects for the promotion of useful knowledge were aided, and to a great degree accomplished, through the instrumentality of the members of our Society.

While the wars which I have referred to disturbed the last half of the eighteenth century, science, invention, intellectual thought, with everything that contributes to the elevation and prosperity of mankind, were not neglected. The volumes written and printed during those fifty years, the activity in the development of the constitution of nature, in the empire of thought, the application of science to the useful arts and the wonderful achievements of those days, even when we contrast them with what is now going on around us, are wonderful in the extreme. *The Century of Inventions*, published by the Marquis of Worcester, illustrative of his investigations in the mechanical sciences, has formed to a certain extent the basis of the operations and thoughts of our mechanical minds. The simple steam engine which was in existence at the beginning of the eighteenth century, was gradually developed by new additions to its structure, promoting its safety and giving it more and more effi-

ciency. By the attention given to mechanical science by the Earl of Stanhope, and above all by the genius of James Watt, the steam engine of those ancient days attained a perfection which seemed at the beginning of the nineteenth century to be such that there was nothing more for man to invent or to aspire to, to increase his powers.

But how does this wonderful invention stand at the present day? The old, simple-acting atmospheric engines, of which I saw some remains in my early childhood, have entirely disappeared, except perhaps in the museums of mechanical objects. The perfected engine of Watt began to be superseded early in the century by the invention of Oliver Evans, a citizen of Pennsylvania, who devised the high-pressure engine, imperfect in the first place in its structure, but wonderful in its effect. Among the examples of his engines, in contrast with those of Boulton and Watt, I may be permitted to call the attention of this meeting to the two engines which for a number of years stood side by side in the building of the Fairmount Water Works, which was erected for the purpose of containing the engines and supplying the city of Philadelphia with water. There was the complicated and ponderous engine of Boulton and Watt, with its walking beam and its great fly-wheel, with the improvements that had been made on the sun and planet movement for the accomplishment of the conversion of vertical power into rotary power. There was a little engine built by Oliver Evans, occupying a space of certainly not more than fifteen feet wide by twenty feet long, with its boiler and all its appendages working under a pressure of 150 pounds to the square inch and performing more work than the elaborately constructed and perfected engine of Boulton and Watt.

In this high-pressure engine of Oliver Evans is found the type of what are now called the compound steam engines of the present day, the steam entering one cylinder at a very high pressure, gradually emerges from that into a second under a diminished pressure, and going on until finally, I believe, it is now passed through at least four cylinders, and terminates at the end of its work under the pressure with which the Boulton and Watt engines were originally worked.

I do not think too much praise can be given to our mechanical inventors. Not only does the steam engine evidence the success of their inventive genius and their perfected labors, but the machin-

ery by which cotton and wool and silk are carded, spun and woven into the beautiful fabrics of the present day, is the product of the last one hundred and fifty years. It will be recollected by my friends who are now here that it was very doubtful towards the close of the eighteenth century whether cotton could be so treated as to separate it from the seeds, to be carded and spun into threads and woven into fabric; but while this doubt was threatening that great product of nature, Whitney gave us the cotton gin, which separated successfully the seeds from the fibres of cotton, preparing it for the cards and introducing it through the gradually perfected machinery for drawing and spinning.

The English inventors and factory men had their genius stimulated to the same end, and the spinning jenny, the mule, and the more elaborate machinery invented by Richard Arkwright, came into use, and, by improvements on the original structures, have arrived at the perfection with which our factories are now equipped and perform their work.

If we turn to other branches of useful knowledge and of science, the first that make an impression on my mind are the wonderful discoveries in astronomy. The old plan of searching the heavens by imperfect instruments has given place to the magnificent telescope of the present day. Photography has come in to the aid of the astronomer, and while his telescope searches out the stars and keeps his instrument in continued harmony with their motion, photography copies the picture of the heavens and opens to us a world not only of knowledge but of imagination.

The chemistry of the world has also undergone great changes. The middle of the eighteenth century was illustrated by the discovery of oxygen gas by Dr. Priestly, and that discovery influenced the science of chemistry to a very great extent in the early years of its progress. But Sir Humphrey Davy and the other later chemical philosophers found out that there were other supporters of combustion than oxygen, and by the combination of those other supporters of combustion we get the basis with which it is possible to combine those gases in the manufacture of important acids.

The whole science of chemistry has been revolutionized, and now the chemists who survive and who received their instructions in the early years of the present century, not only cannot realize what the status of chemistry is at the present day, but are lost in amazement

at the contemplation of the arts by which such revolution and such changes have been accomplished.

In mathematical science the development has, I think, been found equally progressive. We must recollect, in this connection, that while planets used to be discovered by accident and by the visual inspection of the starry heavens, this age has been celebrated by the discovery of a planet purely accomplished by mathematical computation. The great planet Neptune bears testimony to the accuracy of such mathematical formulæ, and perhaps it may not be too much to say that, as years roll around, other great planets may be added to our solar system and the study of the inferior ones will become more nearly perfect by the aid of improved telescopes and the application of photography, so that we may penetrate into the recesses of those planets and perhaps discover that, like our own, they are populated by intelligent beings pursuing, according to the blessings that may be vouchsafed them, the study of what they are capable of in the development of their condition; and possibly, if it is not too much a flight of fancy, that the inhabitants of the earth may develop some machine or instrument by which the gravity of our planet may be overcome and we may go on a voyage of discovery to Venus or Mars.

In medicine, what progress has been made? The old, simple methods followed by a physician, when he was called in to attend a patient, in endeavoring to ascertain the cause of the disease with his imperfect knowledge, reducing inflammation by bleeding, afraid to embark upon any capital surgical operation for fear of disastrous results, have been replaced with greater knowledge. Now the accomplished physician and surgeon steps in and in a very few hours or a very few days determines what is the affliction of his patient and applies the appropriate remedy for changing the constitution of the fluids of the body, and, if need be, courageously takes out his knife and extirpates a tumor, dissevers an arm, opens the throat or the body and by actual inspection of what is the matter lays open the whole case for the application of his remedy, and saves perhaps ten lives at the present day from the inroads of disease, where one life was saved at the beginning of our present century.

In geographical investigation what marvels have the explorations of our travelers exhibited? How more and more are we becoming familiar with the conditions of uncivilized life, the temperature of

the regions it occupies, the products which are yielded by their soil, the direction in which their rivers run, and the whole phenomena of geographical investigation, beginning not only with the appearance of the topography of the earth, its mountains and valleys, but its meteorological conditions and the influences that those conditions have in modifying climatic influences, and either tending to the increase of the natural productions of the soil or interfering with their growth, and admonishing man that there are certain pastures upon which he cannot venture.

What is the geology of the present day as compared with that which prevailed one hundred and fifty years ago? The great geological surveys that have been going on, not only in Europe but in our own country, have developed an amount of knowledge as to the structure and contents of the rocks which strikes us all with admiration. One discovery after another is presented. Men are tracing the various stages of the earth through the fossils which the rocks contain, and while their speculations are not always conclusive on our judgment, yet they open to us fields for contemplation and thought which we all may pursue with intelligence and profit.

We are endeavoring now to unroll the history of the past by the excavations which reveal the ancient temples and the depositories of the knowledge of those who have passed into history, and day by day some tablet, or cylinder, or mummy, is brought forth and the contents of the cylinder or tablet and the wrappings of the mummy give us lessons in the history of man which compel us to say in our hearts: There is nothing new under the sun.

I have referred to photography. At the centennial celebration of this Society, in the year 1843, one of the papers which was presented was a sketch given by Dr. Paul B. Goddard of his investigations in what might be the outgrowth of photography from the daguerrotype process. At that time photography was in its embryo state; very little was known of it. The experiments which he described as to the possibility of transferring upon printed pages or metallic plates the impressions that were taken, showed the dawnings of this great art which, perhaps, I ought to dignify with a higher name and call it science. Look around you now, my friends, at the manifestations of this art which meet you at every step of your progress through the streets of a great metropolis. The familiar features of your friends and children, of the distinguished men of the country and the great natural objects which attract our

attention, are brought forth with a precision and certainty that does not admit of a doubt of their recognition, and in many instances so rounded off by art that they as far excel the productions of the pencil or the brush as the monumental pictures which the God of Nature has planted on the surface of the earth in trees and flowers, valleys and mountains, rivers and lakes, excel those which it is possible by the skill of man in any other direction to produce.

Now we sit at home and we hear the clicking of the telegraph, and it brings us a message from three thousand miles distance in a very little time. We put our mouth to the instrument of the telephone and speak in a natural voice to a man at a hundred yards or a hundred miles or even a thousand miles distant, and there the voice is heard, the interrogatory is answered, and the answer is flashed back before one would think the words had escaped the lips of the interrogator.

So that other marvelous instrument, the phonograph, takes down the very tones of our voice, engraving the words on cylinders of wax, which may be laid by in the closet and after a long interval of time be taken from its recesses and placed again in the machine, and, if the man and his voice have disappeared from the earth and his spirit gone to the God who gave it, that voice can be reproduced and be heard, and the lessons of philosophy perhaps contained in the engraved words may be read for the remembrance of his fellow-beings and fellow-workers, and, more than that, may be preserved and read for the use of the future.

When I think of these marvelous inventions, and turn my thoughts next to what has been accomplished while I have been partaking in the affairs of the world and endeavoring to learn my own lessons of what is going on around me, I marvel more and more at the blessings which have thus been vouchsafed to me. I feel from my knowledge of the men who have grown up and been around me, and lived with me, and participated in the pursuits in which I have engaged, that all this glorious company has been educated up to a higher level than we had any reason to anticipate in our early life, and that we may safely cherish the hope that the good work which has been accomplished is not to terminate with our earthly career, but is to be enlarged, fortified, extended and multiplied for the blessing of the human race, and for the promotion of knowledge and prosperity throughout the earth.

Here I feel that I ought to stop, but I may give one more word,

I think, of encouragement to what has been accomplished by your skill. The old methods of transferring power by means of cog-wheels and ratchets has given way to the utilization of power by means of the pulley and the belt. You enter a factory now and see whirling around you what appears to be simply a loose strap passed over a pulley, with ponderous masses of machinery driven for the production of objects that are useful to mankind, some of them of prime necessity, and all of them recognized as great coadjutors in the work of practical education.

In every large machine shop that we enter we see the evidences of the invention of instruments of precision by which the labors of the mechanician are rendered more easy and more perfect; the planing machine supersedes the old attempt to form a level surface by the application of the hand plane; the turning-lathe accomplishes the formation of very complex forms, far differing from the original cylinder or cone that was the marvelous product of the lathes of old; the gunstock, or the last for a shoe for the human foot, or any complicated form of object, is turned out as if by magic in the improved lathes of the present day, and thus enters into the general mass of useful objects and the evidences of profound invention and skill.

And now, my friends, while I have not especially referred to the history of the American Philosophical Society, I will give you a reason for it, in the fact that it has already been given to you with such marvelous fidelity and truth by the public press that I could add no words to make the record which they have transcribed more complete or full. But I will say in conclusion, that one of the most useful applications of knowledge that these two centuries have witnessed, is the progress of the printing press. In the hall of the child of this Society, the Franklin Institute of Pennsylvania, stands the original printing press of Benjamin Franklin. Contrast that old but powerful instrument of its day with the steam presses that are rattling with their machinery and the operation of their contrivances every hour through the existing busy day. Their work and the result of their labors seems even to exceed what we have witnessed by the utilization of light and electricity. Light and electricity contribute no doubt to the vitality of their existence, but I think one of the most marvelous things for study is to visit the interior of a large, well-equipped printing office of the present day, and see with what rapidity the

notes of the stenographer are turned into the text which appears in the newspaper article of the next day or the magazine article of the next month, the ponderous chapter of the history of inventions, or the treatise on mathematics or chemistry or geology or any other of the kindred sciences; how the text is reduced to printed matter, the type set up, the matrix in which a whole cylinder of matter can be at once developed, formed and put on the whirling cylinders of the press and printed and sped on the wings of the wind throughout the universe.

Such, my friends, is the simple tribute that I am able to pay to this intelligent audience, and the testimony which I am constrained to bear that this earth is gradually growing better and wiser, and that men are beginning to understand more fully the objects for which they were created and to be more helpful to their fellowmen, to prepare us for that higher and more blessed immortality which is promised to the faithful.

President Fraley then presented Prof. Alpheus Hyatt, of the American Academy of Arts and Sciences, Boston, Mass., and spoke as follows:

The American Academy of Arts and Sciences, at Boston, is the sister of this institution, ours having been established in 1743 and the Boston Academy in 1780. They celebrated their centennial in 1880, and no doubt will emulate us in celebrating their one hundred and fiftieth anniversary in 1930; and when that time comes around they will make up the glorious record more fully of that which has been accomplished and also realize the truth of the motto which they bear on their seal.

Prof. Alpheus Hyatt, of the American Academy of Arts and Sciences, Boston, Mass., addressed the Society as follows:

Mr. President and Members of the American Philosophical Society:—I came this morning intending, of course, to listen to the two gentlemen who had been announced to speak, with no anticipation whatever that I should be called upon to give anything more than perhaps a mere statement of the subject of my paper.

I labor under the double disadvantage of having prepared therefor no specimens, having brought before you nothing to make my theme comprehensive, and also the final disadvantage of having no blackboard; but I will do the best I can to make my point comprehensible.

The subject which I proposed to present to the Society is what I should call the "Phylogeny of an Acquired Characteristic," the history of one single characteristic followed out from its earliest inception in the type of cephalopods through various stages of its evolution to its final disappearance in the same type. The object is to give a solid basis to certain theories of evolution.

You all, of course, know that in the present treatment of the problem of evolution everything depends on having some specific object. It is well enough to speculate, it is well enough to state the Darwinian hypothesis, it is well enough to have this hypothesis or that point of view and to argue about them, but to come down to the facts which lie at the bottom of these, and to follow them through all the phases of their evolution is, of course, difficult and largely a matter of chance in every department of research.

In this case, one characteristic happens to be provable, and furnishes the subject which I have in hand for special investigation. The earliest shells, those which are primitive in shape, are cones like this. (Illustrating.) They are divided by partitions and have certain internal characteristics which distinguish them. The next shape is bent, as if I were to take this cone and bend it without crushing in one side. The next form is loosely coiled, as if I doubled this paper cone without depressing one side, the cone not coming in contact. The next stage of evolution is one in which the cone not only doubles on itself by growth, but doubles so closely that it actually flattens this inner side, and then, in place of being able to see these inside convolutions in the next state of evolution, they are concealed by the downward growth of the outside. So that the shell, growing gradually, first like a rope coiled up, and then eventually, if you can imagine the sides of the coil growing inwards as they progress, so as to cover up the interior, you would see the last or outside convolution with a depression like that (illustrating) in a horseshoe shape, on the inner side. These whorls, the first of them in the Devonian and Silurian period, are always rounded, so that the section is very much like a section of the end of that cone, it has no depression on the inside. Then, as the

forms coil tighter and tighter, one whorl lying over the other, the inner whorl presses upon and obliges the outer whorl to form this depression on the inner side. When the shell gets old the whorl quits the spiral and grows out straight, and when that period begins in old age this depression, which is formed where the whorls close up, gradually disappears, so that in extreme old age you get a return to the rounded outline.

Thus you get throughout the earlier systems in the earth's history, throughout the Silurian and Devonian period, a transient condition. You will find that whenever this depression occurs it is always because one whorl laps over another. When, in the course of growth, the shell passes by the whorl, that bay or depression disappears, so that you get in every fossil the proof that this characteristic is a transient one, that when it occurred it was through the mechanical action of the growth of one whorl of the shell over another, as much so as a dent in a piece of putty when you put your fist in it; in other words, it is not in the organism and in any shape which would enable us to say it was inherited. The Weissman hypothesis is that evolution has taken place by other forces than those which modify the organization from the exterior. He says that no characteristic which is acquired in this way, mechanically, by growth or the action of the externals in any way on the animal, can be inherited. It is not inherited. It makes no impression on the organism so that it can be inherited.

We can get the history of this characteristic throughout the earlier periods and it justifies the hypothesis. It was supposed by me for several years to be one of the strongest points in favor of the hypothesis, that an acquired characteristic made no impression on the germ and was, in fact, non-inherited.

This last winter, following out an investigation begun in connection with the geological survey of Texas in the carboniferous deposits of that region, I was led to extend my investigation in regard to their development and general history. The result was the finding that in certain series of the carboniferous this characteristic was indubitably inherited. I found in the young of close-coiled carboniferous forms, shells which were unquestionably close coiled in their adult condition, that in the young of these there was a repetition of the characteristics of the adults of the Silurian and Devonian. In these very young forms the whorls do not touch when they first begin to grow, but are all open, as much so as if I bent this piece

of paper this way and simply curled it in that shape. (Illustrating.) The young of these carboniferous forms are formed like that; the whorls do not touch. When you take a young cone like that and examine this portion of it you find this depression, which was purely mechanical in origin throughout the Silurian and Devonian, and dependent upon close coiling is here inherited before the whorls touch.

That, then, seems to be as far as possible, without demonstration by experiment, a clear case of the acquisition of a characteristic in the earlier periods of the evolution of a group, through the purely mechanical effect produced by the mode of growth of the shell, and then the inheriting of the same in the young of carboniferous forms before any of those mechanical causes which originated this characteristic could have their influence on the growth of the shell. While it was still young, still uncoiled, still like its ancestors in every way, it inherits this acquired character, which never appeared in them until later in life, and was retained in them only so long as the originating mechanical causes continued to bear on the shell during its growth.

Then to complete the history after the carboniferous, I have investigated the different forms to see if it were continuous. We find it is present in the same type throughout the jura, cretaceous and trias, and finally, examining the last existing forms, of which there are only four species, of nautiloids now living, the same characteristic is well developed in the young.

Then following up another line, taking the Ammonoids, which is the more complicated type, and which terminates in the cretaceous, we can pass through the entire group, and we find this characteristic increasing and becoming more and more important. Finally, we strike in the jura certain degraded forms, and ultimately in the cretaceous forms which are the reverse of those with which they began. Just as in old age we are in a measure the reverse of our adult period, just as in that condition we put on certain infantile characteristics, which are produced by the wear and tear of life, these types through their evolutionary history go back on their history, and part with characteristics that distinguish their higher development and become simpler. Instead of being coiled up they become uncoiled, having young which are coiled up and adults which are uncoiled, and in following this characteristic through that long reverse series of forms it is found to disappear precisely in accordance with certain

laws, which show that in the degeneracy of types, as well as in the old age of individuals, there is a decrease and a final disuse of characteristics which have been introduced during the rise of the group.

The history of this characteristic follows the same law, and is precisely in accordance with the history of other parts of the animal, and precisely parallel with those which no one can deny to be hereditary. It will be very difficult for those who take the view that acquired characteristics cannot be inherited, to prove that this is not an acquired characteristic or that it is not inherited. It seems to me, as far as can be shown, without, of course, the direct demonstration of experiment, that it is an acquired characteristic of purely mechanical origin which becomes inherited in the carboniferous.

A MEMBER: I should like to know what is the natural size of these shells.

PROF. HYATT: They are of all sizes. The largest of those described perhaps are three inches in diameter, others when full grown being much larger. They are all of good size for observation.

Prof. Hubert A. Newton, of New Haven, Conn., representing the Royal Society of Edinburgh, next addressed the Society, as follows:

I have to apologize somewhat in that I came to the rooms not expecting to speak to you. I have, however, one point which I think will interest the members of this Society if they will give me a few minutes to develop it, and that is, the force which acts on the small bodies sent off from comets and which form our shooting stars.

There are in the comets so many questions that we cannot answer, so many curious and wonderful phenomena that are unexplained, that I am sure you will accept any explanation of any of them that seems plausible, as a matter of interest. From a comet there is continually driven off matter forming the tail, a light substance, and astronomers are agreed that the force that acts on the matter which forms the tail is a repulsive force from the sun acting inversely as the square of the distance, the force of the repulsion being greater than that of attraction.

Not only is this true, but different parts of that tail are acted upon by repulsive forces of different powers; otherwise the tail

would form across the sky a single line instead of a broad, expanded mass of light such as we see. From the comet, however, there are driven off also, or there are separated other things entirely distinct from the tail, small bodies, which are not thus driven away, which are not visible, but follow along closely in the path of the comet, and whenever the occasion comes, that is when we go through a group of them, those give us our shooting stars.

The Biela comet, in the period about 1840, passed near to Jupiter. At that time it was turned pretty sharply out of its orbit, the inclination of the orbit being turned several degrees, and the node being carried forward also several degrees, represented by several days in the time at which we crossed the path of the comet.

After 1840 the bodies which formed the meteors that were met in 1872 and in 1885 were separated from one or other parts of the Biela comet. I say after 1840, because if they had been separated earlier they would have given us a different radiant in the skies, the one given by the Biela meteors of 1838. The radiant was changed, the node was changed, all to correspond to the new orbit, and these bodies could not have been turned in that way had they been before scattered, because the force that acted on them, the attraction of Jupiter, would have scattered the group instead of giving us that single compact group through which we passed in 1872 and 1885 in the course of four or five hours, and the bulk of them even in two hours.

In 1872, the comet was something like 200,000,000 miles away from the bodies that we met as we passed through them on the 27th of November, giving us a brilliant shower. Thirteen years later we passed through the group again, and then the comet was something like 300,000,000 miles ahead of the group. So that some of the particles, leaving the comet between 1840 and 1870, had gained and others between 1840 and 1885 had fallen behind.

What should separate those particles? What are the forces which carried off those particles so many miles—200,000,000 miles on the one hand and 300,000,000 miles on the other, in round numbers? The force that acts on them must be a force acting in one plane, that is, the plane of the orbit of the comet. Any force acting in other planes would have scattered the group and we would not have met them as a single definite group at the times named; but if it acts in the plane, only scattering them on the plane, they would be together as we saw them.

In that plane, it must be either an impulsive force acting once or it must be a constant force acting continually. The only bodies in that plane are the comets and the sun, and if the force is a continuous force it must be from the comet or from the sun. It is almost inconceivable to suppose that the comet could have sent them off, either impulsively or continuously, in such a way as to give us the distance of 200,000,000 and 300,000,000 miles in the course of thirty years; it would require far more than any velocity that we can give in our terrestrial experiments, and we have no reason to suppose that there is any such power of impulsion. Moreover, if the impulsion came from the comet, they would go in all directions and their character, as being in a plane, would have been entirely lost.

We are then thrown back on this one hypothesis, that the sun is the source of that force. In other words, we are led to extend the idea that I gave you in the beginning, and which is accepted by astronomers, that the material which goes off from the comet, after it leaves it, is subject to a force like that of attraction but differing in its intensity. In the case of the tail, it is a repulsive force. To satisfy these conditions of separation, part in one direction and part in the other, from the comet, we must have an attraction in the one case exceeding the attraction of gravitation and, in the other, an attraction less than the attraction of gravitation. In other words, these little bodies of hard matter that go off from the comet and follow very nearly in its train are acted on not in proportion to the force that steadily acts on the planets in their orbits.

I see no escape, myself, from this conclusion. What it means, I must leave to you to decide. Our experiments make it very improbable that the attraction of matter differs in any way from proportion to the mass. It looks to me as though the more natural explanation is that, in some way, the materials which go off from the comet carry with them a load of electricity, or something of that kind, by which they have a permanent repulsion or permanent attraction sufficient to change the orbit altogether, not in kind, but in a steady change, throwing them into a new orbit with a new period, and thus scattering them.

What that added force must be, we cannot very well tell, because it differs according to the place in the orbit where the disintegration takes place. If that disintegration takes place near the sun, it is one thing; if it takes place near Jupiter, it is another. It

looks more to me as though there was a disintegration all along the line of the comet's orbit, giving us small particles with all sorts of loads of electricity and all sorts of differences of central attraction and differences of orbits, and thus they get widely scattered so as to give us the showers a long distance from the comet itself. The amount of this change would have to be something like the tenth part, possibly, or something less than that. I should think that all the phenomena could be explained by a change amounting to one-tenth of the attraction; that is, if the small particle carries a load of electricity such as to diminish the attraction to say nine-tenths of the original attractive force of the sun, or increase it to eleven-tenths, it will explain the phenomena.

If that is the explanation, we come to this further conclusion of interest, that the space through which these comets move is not such that the electricity which the particle carries can be lost. Another practical point would be that, in the discussion of the separation of these comet masses that through the telescope we see going on as the comets pass the sun, there might fairly be introduced an unknown correction of the force of central attraction.

A MEMBER: Have you gentlemen, who have made a study of this very interesting subject which you have been discoursing on, arrived at any hypothesis as to what broke up the Biela comet?

PROF. NEWTON: I can only answer as a working hypothesis, in my own mind, is that a mass, not surrounded by an atmosphere, coming down from the cold into a warmer region near the sun, becomes heated up, and in that heating there is a disintegration going on. If you put the pieces of a meteorite into a vacuum, and heat them, you will get gases that will be something like those which are thrown off from the tail of a comet, and the comet coming down near the sun, with the hot, scorching effect entirely undiminished by a thick atmosphere, would have pieces broken off, giving fresh surfaces. An immense amount of action of some sort follows, and those pieces would naturally go off under such excitement, carrying with them, as I conceive, a load of electricity. The process goes on in almost all our comets. It is not in Biela alone that we see comets going off to pieces. Scores of comets have shown that same breaking up under the telescope.

Adjourned.

In the afternoon the Society and guests attended a reception tendered by the Drexel Institute.

PHILADELPHIA, Wednesday, May 24, 1893, 11 A.M.

The Society was called to order at 11 A.M. by President Fraley, who presented Dr. Daniel C. Gilman, President of the Johns Hopkins University, who read an address on the "Present Aspects of Science in America."

After presenting the congratulations of the Johns Hopkins University to the American Philosophical Society, he proceeded to discuss the various agencies which are concerned in the advancement of knowledge, namely, museums and libraries, universities and colleges, scientific instruments and apparatus, agencies for the encouragement of research, and publications. Under each of these five heads, the speaker considered the actual condition of science in America, adding occasional historical illustrations. The paper included a sketch of the contributions made to each of the principal branches of natural science by American investigators.

President Fraley next introduced Rt. Rev. John J. Keane, President of the Catholic University of America, at Washington, who addressed the Society upon the subject of "Philosophy's Place Among the Sciences," as follows:

Mr. President and Fellow-members of the American Philosophical Society, Ladies and Gentlemen:—In the name of one of the very youngest of our American institutions of learning, I offer the tribute of my respect and reverence to the first association of the kind in our country. In our New World a century and a half is a very hoary old age, and a society that has with honor lived during that period can very well look down in a spirit of patriarchal dignity and superiority on every other institution that sets to work under its guidance and in pursuance of its example.

I say in the name of our young institution in Washington that to follow that guidance shall be our constant endeavor and our highest ambition. We have long since come to the conviction, so well

stated just now by Dr. Gilman, that between science and religion there cannot be an antagonism, only we go a step farther than that which he indicated: We are not willing merely to regard science as the handmaid of religion, but we look upon science as the sister of religion; they are both from the same Father, and He has not made one the servant of the other; He has made them sisters one to the other, and it is in that spirit of sisterhood that in our institution they are to march hand in hand through the generations to come, and in doing that we are always going to keep our eye on the grand old association in Philadelphia. We are going to have its object of extending the boundaries of human knowledge and of bringing its treasures within the reach of the largest possible number, and in pursuance of that we shall always promise the tribute of our reverence and our loyalty to the grand old pioneer.

Yesterday, the keynote to this centennial celebration was given in the address of our venerable President. He showed us that the century and a half during which this Society has lived has been a period of progress along all the lines of human knowledge and of human activity. As lovers of mankind, we rejoice in that perspective and we give thanks to the Author of all good gifts, to the Father of Lights, who has so guided the researches of the past and led them to results that are so conducive to human utility.

To-day, as Americans, we look on that same perspective with honest pride, listening to the admirable presentation made by Dr. Gilman of what America has done in helping on that progress in the lines of science, and it could be shown by other specialists how America, in every other field of human thought and action, has taken her part nobly.

There is one department, however, in which it might be alleged that America has been rather in the background. America has added very little, comparatively, to the world's stock of philosophic thought. This is not owing to any want of philosophical ability or of what may be termed the philosophic spirit in our country, but it is because the energies of a new country have naturally been taken up in the tremendous development of her growth. Now that that growth is approaching its maturity, the natural tendency to philosophize asserts itself; but it behooves us, looking at the present and glancing forward to the future as far as we can, to provide that the philosophizing of the present and of the future shall chime with all the advance of human thought and of human knowledge.

We do not want a philosophy that will ignore any acquisition of human knowledge. Hence, it becomes of great importance that we should rightly estimate the relations that exist and must exist between science and philosophy.

In glancing over the sum of human knowledge, there are two things that strike us with almost equal force—we cannot but wonder at how little we know and we cannot but wonder at how much we know. Paschal has said very truly that that man has advanced but a short way in the road of knowledge who has not discovered that the amount which he does not know incomparably surpasses the amount he does know. There are still infinities of things that are beyond the reach of our ken, and yet we cannot but marvel at the amount of knowledge that we have drawn from the facts that are within our reach. The reason of that is because, as Schelling says, knowledge has two poles, the objective and the subjective poles, of cognition. The object of cognition may remain the same; the subjective conditions vary infinitely—subjective aptitudes, subjective fitnesses. The dewdrop has a message for the poet that the scientist may have no ears to hear, and the dewdrop has revelations for the physicist to which the poet may be absolutely impervious. The vibrations of air are one thing for Helmholtz; they are quite a different thing for Wagner. We remember how, in our childhood, we played with our kaleidoscopes and saw how the same little bits of broken glass, continuously assuming their varied forms, could give us infinities of beauty, and that was not, by any means, only a work of imagination. So the facts that stand before us are many sided in their phases, and every phase appeals to some aspect of human intelligence, and when we put into combination the endless variety of phases of things, and the endless variety of intellectual capabilities, then we come to understand how it is that, from the facts within our reach, the sum total of human intelligence has grown so tremendous.

This variety of human capabilities coming in contact with the intelligibility of things, is not only a legitimate and an unquestionable fact, but it is an ultimate fact, a fact whose consequences impose themselves upon us, not with a necessity that is regardless of distinction between true and false, but with the necessity of the truth. The consequences of that endless variety of human capabilities are in the sum total of knowledge an endless harmony, although in the comparison of individual fitnesses and individual

intellectual activity it may often seem to lead to contradiction. Why should it lead to real or to apparent contradiction?

Even within the limits of severe knowledge, laying aside fancy and poetry, there is an immense difference between, leading to a divergence between, experimental observation and philosophic or speculative thought. Some minds are made for the one, some minds are made for the other. It is only the rarer minds, the immensely comprehensive minds, that seem capable of fully combining these two qualities in perfection. We know that this combination did exist in Aristotle—equally wonderful, equally admirable as a scientific observer and as a philosophic speculator; but in the average of men the one or the other fitness is very apt to predominate, and, if it is predominant, is apt to run into exclusiveness, and, if that tendency to exclusiveness be not counteracted, after awhile the scientific observer and the philosophic thinker may have drifted so far apart that they seem to be in conflict, in contradiction, that they may seem to find it impossible to come into agreement or even to find a common ground for argument.

When both gifts are combined in some great man, then it becomes evident to him, and his experience serves as a demonstration to others, that between the two—between the scientific and the philosophical—there cannot be a contradiction. But whenever the speculative or the experimental claims for itself exclusiveness, then the result is one-sidedness, and the one-sided thinker is apt to tumble over into chaos, or, what is almost equally bad, to rebound to an opposite extreme. So it is with individuals, so it is with epochs, with generations. Some great man puts the stamp of his mind on his epoch, and it is philosophic or it is positivist and scientific; and in the epoch even more than in the individual, because the epoch has time to work out the logic of things which may not be given to the individual, extremism or one-sidedness is certain to lead to a rebound, to a reaction that tends towards and may reach the opposite extreme.

During our century and a half, this has been made abundantly evident to the world. When our Society began, Kant was calmly investigating the value and the limits of human knowledge, working out what posterity recognized to be objective scepticism. It led to the rebound of extreme idealism, led by such men as Fichte, Schelling and Hegel, and that idealism went to such extremes as simply to bring philosophy into contempt. It led to the opposite

rebound of materialism, reaching its climax in the positivism of Auguste Comte, and the extremes of that idealism have almost justified the extremes, also, of the empirical school.

At present we see a rebound from materialism and empiricism. The result is twofold. Wherever philosophic thought has grown languid and weak under the opiate influences of materialism and skepticism, wherever it merely has power to lift itself up and be heard, it seems to totter into mere agnosticism; but wherever, on the contrary, philosophic thought has retained some of the manly vigor which recognizes that the human intellect is not made for nescience but for knowledge, not made for darkness but for light, then philosophy stands up and asserts itself, asserts its right to remind science that it does not fill the whole world of human thinking, and demands that those relations between science and philosophy shall be remembered and shall be observed, upon which the reasonableness or utility of both equally depends.

What are those relations? Science works according to certain principles which it presupposes. These principles are very elementary. The whole is, and must be, greater than any of its parts. All the operations of nature take place, and must take place, in space and in time. Every effect presupposes, and must presuppose, a cause; and is, and must be, proportionate to its cause. Nature itself is a reality and not a fiction. It has in it those elements that make it possible for a man from facts to rise to laws and from laws to build up systems. All the notions of equality and inequality, of proportion and relation—all these things science works with, all these things science presupposes. Science did not make them, science did not discover them, science did not receive them even from mathematics. Mathematics, itself, presupposes them and works with them. Where do they come from? The scientist may accept these principles unconsciously, he may forget his debt to philosophy, but he does not by that forgetfulness cancel the debt.

More than that, when a science has done its best, and by the application of these principles has made and tested its methods, carried on its observations and then tested its results, all is not done. These single facts have to be woven, have to be fixed into the great mosaic of truth. Science stands side by side with other sciences, and the scientist in any department must every now and then, if he is loyal to human intelligence, look over the fence of his own narrow boundary, recognize the fields of thought that are beyond

him, estimate the relation and agreement between his results and those which they are working out, and not merely try to estimate how it is as between him and his nearest neighbor in the departments of science, but how it is between him and them all.

Who is going to do this? No individual science can do it; no mere coming together of all the sciences can accomplish it. An arbiter is needed, an arbiter that can stand on a hilltop and survey all; and that arbiter of all the sciences—the one that stands on the hilltop and corrects blunders and utters notes of warning, and knows how, from hypotheses, to sift out certitudes and from mistakes to sift out truths, and to take all the little bits that each supplies and weave them in the harmony of truth—is philosophy; and the fact that her point of view is so much higher and so much more comprehensive than that of any science in particular, enables her to direct the sciences in their work and to point out any part of the great horizon in which the light is seen to be breaking forth.

Such is the natural relation between science and philosophy, the relation that they must have in the nature of things. How is it *de facto* in the age in which we live? It is a noteworthy fact that, in our age, so many scientific men are developing into philosophic thinkers. Wundt, after writing on physics, physiology and experimental psychology, gives us his system of philosophy. Mivart, while plying his scalpel, learns for himself and publishes to the world the deeper lessons from nature and the higher meaning of truth and the value and method of reasoning. From the physiological laboratory Du Bois Raymond surveys the Seven World Riddles, and Lewes launches out into the problems of life and mind.

These facts, simple indications of multitudes that might be enumerated, show that the most accurate scientific research is compatible with the profoundest philosophic thinking. Nay, more, it shows that science—when it is loyal to truth, when it is logical, when it is consistent, when it is human—must lead up to philosophic thinking. The same appears when we institute a comparison between the methods of science, and of philosophy. First of all, let us observe that every science has its own specialties of method which no other science may share with it. The physicist has one method, the chemist has another, so have the biologist and the astronomer.

But these differences of detail in the methods of the individual

sciences do not, by any means, prove any incompatibility between the sciences or their general methods. Apply the truth, and we recognize at once that, while there must exist distinctive differences between the methods of any science, or of all the sciences, and the methods of philosophy, these distinctive differences are no proof of incompatibility between philosophy and sciences or between their methods.

More than that, the method observed by all sciences is, in its ultimate analysis, generalization, which is a process of abstraction. Without generalization, without abstraction, it would be simply impossible to rise from the notion of fact to the notion of law. When the chemist finds that this oxygen, in this balloon, takes just so much of this hydrogen in this balloon in order to combine into water, he extends this proportion to all oxygen and all hydrogen, and to all experiments with them—past, present and to come—not by scientific observation, but by generalization, by abstraction, by the fundamental process of all thinking. When the physicist finds that this piece of spar gives double refraction, he concludes the same of all samples of that substance, and that without at all needing to experiment with the rest. When the physiologist finds that the blood in this man is composed of white and red corpuscles, he does not need to dissect all mankind in order to reach the conclusion that the blood of every man is composed in the same way. Thus we recognize that science is constantly making use of one great operation, which is the fundamental unity of all scientific method, and that is generalization, abstraction.

Then comes the mathematician, whose method means abstraction on a higher plane. He shows that two and two make four, whether it be two and two atoms, or two and two planets, or two and two ideas; and he applies his principles of number and weight and measure, his notions of quality and equality and proportion, to all things, and works out at his desk the system of the universe. It is a remarkable fact that the great fundamental, dominant principle of all physical science in our age, the conservation of force, was wrought out mathematically, by Leibnitz, one hundred and fifty years before it was proved experimentally by Joule.

One step more up that ladder of abstraction and we reach the operations of philosophy. It widens our view, giving us not merely the perspective of this science and of that science and of all sciences lying side by side, interlacing and working together in the

production of the world's harmony, but it opens before us a perspective that embraces all things, a perspective embracing the infinite and the atom, with all the intervening grades of force and of life, the grand hierarchy of being, of causing, of becoming; therefore, the advance from science to philosophy is but an ascent from one grade of abstraction to another, without jar or hindrance, for those whose minds are keen enough for analysis and broad enough for synthesis.

Yet another motive which leads, or rather forces, the logical scientist into philosophy is the fact that problems exist and demand a solution which no amount of scientific research can solve. What is the origin of all? What is the aim of evolution? What is the nature of the human soul, its whence, its whither? What is the real value of human life? What are its duties, its rewards, its destiny? Any individual scientist may brush these questions aside, but there they stand, they confront mankind, they ever have confronted mankind, they ever have forced mankind to its highest and its deepest and its noblest thinking. They demand a reply, they prove with the very evidence of intuition that a reply to these problems is of greater importance than a reply to any of the problems ever started by physics or by chemistry; and just in proportion as special research drifts away from facing these problems they cry out all the more loudly in the ear of humanity and tell man that he dare not ignore them. The man who stands ankle deep in the rivulet may laugh at the shallowness of the little stream, but his merriment does not fathom the sea into which that stream and a thousand others are pouring; and to sound the depths of that all-comprising truth into which the separate branches of knowledge empty their threads of facts is the proper office of philosophy.

What system of philosophy is going to do this? What system of philosophy can we Americans at the close of the nineteenth century accept? It must be a philosophy that shall have an eye on the past and an eye on the future; that is to say, first, it must be a fair and balanced philosophy that shall avoid extremes, extremes which are fatal alike to empirical and to speculative thought. It must avoid one-sidedness, it must keep clear of materialism and of idealism, of skepticism and of dogmatism, of pantheism and of atheism; it must be balanced, it must be an all-around philosophy, it must be the *via media*. Secondly, it must be adaptable, it must be firm enough to hold fast to every addition which science may make to

the sum total of human knowledge, fearless enough to welcome them all, knowing that fact can never contradict fact and that truth can never be in antagonism to truth; and it must be elastic enough to meet the result of philosophic research, holding on to what is, pressing on to what is to come. It must be, in the third place, a reflection of all those elements which in the development of thought persist because true.

We have men around us building up grand systems of philosophy and those systems die one after another, and yet, as the scientist shows us to-day the structure of the beings that lived ages and ages ago and left a substratum of fact after them, so these systems of thought that come and go and die leave something after them. No system of thought is totally false, though few systems of thought can claim to be totally true. And so our system of philosophy must be able to hold on to all that is true, no matter where it comes from, to hold on to the persistent, to hold on to that which is eternal because it is true.

May I be permitted in conclusion to ask your attention to what some may consider a singular fact in the world of thought at the close of the nineteenth century. Let me ask your attention to that grand old man whom we Catholics I think have a right to be proud of, Leo XIII, who on the one hand calls the world again to study the old scholastic philosophy, and, on the other hand, endows out of his own means astronomical observatories and laboratories of physics and of chemistry. That man is convinced that there is in that old philosophy a body of principles that are the truth, a body of principles that therefore are everlasting, a body of principles that therefore can guide science as well at the end of the nineteenth century as they did in the middle of the thirteenth. He shows that that philosophy is not a fossil, but a system of living principles ready to take in all that the scalpel, the retort and the lens can ever show us, and to teach all the wondrous progress of the science of the future how it is to weave itself into the great harmony of truth and is yet to shed its refulgence on the world. He shows us that it is possible for a system devised by Aristotle and developed by Aquinas to receive yet further development, and to answer yet or to help mankind to answer all the mighty problems in nature and above it that press upon the mind of man.

Shall not America do something towards helping the world to

such a philosophy? America aims at giving to the world not only the best machines the world has ever seen, but the best men the world has ever seen; Americans make the best men that civilization has yet produced. She is therefore to help the world on to the best thought that the world has ever yet beheld. I hope we recognize that human thought will not be at its best until scientific thought and philosophic thought are wedded together in proper harmony; and shall not this grand old Society, which has so beautifully guided America in her thinking and researches of the past, guide and help America in the study of that glorious problem which she in the future must help the world to solve?

Adjourned.

Wednesday, May 24—3 o'clock P.M. Reception by the Board of Directors of Girard College at the College.

9 o'clock P.M. Reception by the "Penn Club."

PHILADELPHIA, Thursday, May 25, 1893, 11 A.M.

The Society was called to order by Dr. Ruschenberger, who presided over the meeting.

Dr. Samuel A. Green having been introduced, read a paper on "Benjamin Franklin, Printer, Patriot and Philosopher," as follows:

At this anniversary meeting of the American Philosophical Society the name of the founder readily suggests itself; and for that reason I have taken as the subject of my paper the career of Benjamin Franklin, who was during his lifetime, with possibly a single exception, the most conspicuous character in American history.

Whether considered as a printer, a patriot, or a philosopher, Franklin challenges our highest regard and our deepest admiration. Taking him for all in all, in his moral and intellectual proportions, he is the most symmetrically developed man that this country has produced. In popular phrase he was a great all-round man, able to meet any emergency and ever ready to cope with any situation. In many ways he has left behind him the imprint of his mind and

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of his work on the activities of the present day, to an extent that is unparalleled. To a large degree he had a knack of doing the right thing at the right time, which is epitomized by the American people as horse sense,—a quality which justly assigns him to a high place among men of worldly wisdom. He had a faculty of performing the most arduous labors on the most momentous occasions in such a quiet way that even his nearest friends often were entirely ignorant of his agency in the matter; and little did he care whether the credit of the deed came to him or went elsewhere. He seemed to turn off work of the highest order as easily as the sun shines or the rain falls, and just as unconsciously. A marked peculiarity with him was doing his whole duty on all occasions, without making a fuss about it. An estimate of his father's character, given in Franklin's own words, would apply equally well to himself: "His great excellence was his sound understanding, and his solid judgment in prudential matters, both in private and public affairs."

In order to trace some of these qualities towards their source, it is necessary to examine the causes at work during Franklin's early life, and even to go back still further and learn what influences had been brought to bear on his ancestors; since the influence of heredity must in this, as in every such case, be considered. It has been wittily said by a writer—so distinguished in many ways that I hardly know whether to speak of him as a poet or a physician, but whom all will recognize as "the Autocrat of the Breakfast Table" —that a man's education begins a hundred years before he is born. I am almost tempted to add that even then he is putting on only the finishing touches of his training. A man is a composite being, both in body and soul, with a long line of ancestry whose beginning it is impossible to trace; and every succeeding generation only helps to bind and weld together the various and innumerable qualities which make up his personality, though they be modified by countless circumstances that form his later education, and for which he alone is responsible. Of Franklin it may be said that he came of sturdy stock, none better in New England, poor in this world's goods, but rich in faith and the hope of immortality. On both sides of the family his ancestors, as far back as the records go, were pious folk, hard-working and God-fearing. They knew the value of time and money, and they also placed a high estimate on learning and wisdom. From such a source it fell to his lot to inherit life, and his heritage was better than silver or gold.

Benjamin Franklin was born on January 6, 1706,—according to the old style of reckoning time,—in a modest dwelling near the head of Milk street, Boston. Just across the way was the South Meeting-house, belonging to the Third Church of Christ, of which Franklin's parents were members, and at its services were constant attendants. In this sanctuary the little infant, on the day of his birth, was baptized by Samuel Willard, the minister, who duly entered the fact in the church record. With our modern ideas of sanitary precaution, it might now seem to us somewhat imprudent to take into the open air, even for a very short distance, a delicate *neonatus*, whose earthly pilgrimage was spanned by an existence of only a few hours, and to carry him to an unwarmed meeting-house, in the midst of a New England winter, even for the purpose of receiving the rite of Christian baptism; but our pious forefathers thought otherwise. At the same time, prayers were offered up for the speedy recovery of the mother; and the knowledge of this fact was a source of great comfort and consolation to the family household.

Benjamin's father, Josiah Franklin, was English-born,—coming from Northamptonshire, where the family had lived for many generations; the same county from which also the family of George Washington came. For a long period the men had been rigorous toilers, earning their livelihood by the sweat of their brow, and many of them were blacksmiths. Benjamin's mother, Abiah Folger, was a native of the island of Nantucket, and his father's second wife. Her father, Peter Folger, was a man of such distinguished probity that when he was acting as one of five commissioners appointed to measure and lay out the land on that island, it was decreed that any three out of the five might do the business provided he was one of them. What a commentary on his integrity, and what a tribute to his personal worth! The resemblance between the philosopher and Peter Folger, a later kinsman, as seen in his portrait, is very striking; and it may well have been said by his neighbors that in his younger days Benjamin favored his mother's family in looks.

Franklin's father owned a few books, mostly theological, and on these the lad used to browse, and pick up whatever he could in order to satisfy his inquiring mind, though he found it dry picking. There is no better exercise for a bright boy than to turn him loose

in a library, and let him run, day after day and week after week, nibbling here and tasting there, as whim or fancy dictates.

Franklin's early surroundings were of a humble character, and his chances of brilliant success in life, as seen from a worldly point of view, were slim and discouraging. As a boy he played in the street, went barefooted in summer, fished from the wharves at flood tide, and snow-balled on the Common in winter; and he got into petty scrapes, just as other youngsters of that period did, and just as they ever will do, so long as boys are boys, because boyhood is brimful of human nature. He was no exception to the general run of youthful humanity, any further than that he was a bright, clever lad, with a good memory, and that he was fond of reading and always hated shams. He would never have been picked out of a group of urchins as one ordained to help mold the destiny of a new nation, or as one likely to stand before kings. But is it not written, "Seest thou a man diligent in business? he shall stand before kings"?

Early accustomed to habits of strict frugality, Franklin also imbibed those peculiar notions which laid the foundation of a remarkable and distinguished career. Brought up to work, he was not afraid of labor when apprenticed as a boy in the printing-office of his brother James, the owner and editor of *The New-England Courant*, where he often did a man's stint. His early advantages at school were very limited, being confined to a period of less than two years, and that, too, before he was eleven years of age. An apprenticeship in a printing office at any time is a good school of instruction, though one hundred and seventy-five years ago Franklin did not find it an agreeable one. His experience at that time, however, stood him in good stead on many later occasions.

The question naturally comes up, "What special influences were brought to bear on the young apprentice during the plastic period of his life which made him afterward the great philosopher and the sagacious statesman, and above all the apostle of common sense?"

This is answered in part by himself in his charming *Autobiography*, where he speaks of his fondness for reading, and of the difficulty he experienced during his younger days in getting the right kind of books. He mentions by title Defoe's *Essays on Projects*, and Cotton Mather's *Essays to do Good*, otherwise called *Bonifacius*, as two works which had a lasting influence on his after-life. Defoe's book is a very rare work, so rare, indeed, that its very existence has been doubted, and it has been even asserted positively that no such book

was ever written; but the assertion is wrong. It has been said, too, that Franklin had in mind, when he wrote this part of his *Autobiography*, Defoe's *Complete English Tradesman*, and that he was then thinking of this work; but it was not so. The great printer in his younger days had handled too much type to make a mistake in the title of a book. Eight or nine years before his birth *An Essay upon Projects* was published in London, written by the same author who afterward wrote that prose epic *Robinson Crusoe*, which charmed us all so much in our boyhood. In the introduction to the Essay the author terms the age in which he wrote "the projecting age," and in the body of the work he refers to many schemes which have since crystallized into practical projects, and are now considered necessary institutions of the present age. Besides other subjects he refers to Banks, Highways, Assurances, Pension Offices or Savings Banks, Friendly Societies, and Academies, all which to-day are recognized as actual problems in business life. In his chapter on "Assurances" is found the origin of modern Fire Insurance companies; and in that on "Fools," or Idiots, there is more than a suggestion of Insane Asylums and other institutions for the care and comfort of persons who are mentally unsound. The Essay, or collection of Essays, is well written, and in style furnished a good model for the readers of that century, although now it would hardly be considered an attractive book for boys. It may be asserted, in the light of Franklin's statement, that this work gave the young philosopher a turn of thought which ever afterward he followed. In the treatment of the various subjects of the different chapters there is a decided flavor of practical wisdom for everyday use, which seems to have clung to Franklin during his whole life.

The other little book mentioned in the *Autobiography* was first published in the year 1710; and, as the author was settled as a colleague pastor over the church where the Franklin family afterward attended worship, it seems natural that the work should have been introduced at an early period into the Franklin household, where it surely found eager readers. The book is scarcely ever looked at nowadays, much less is it ever read; but it contains some grains of wheat scattered through the chaff. The following extracts from its pages are quite Franklinesque in their character:

Take a Catalogue of all your more **Distant Relatives.** . . . Think; *Wherein may I pursue the Good of such a Relative* (page 72)?

Have alwayes lying by you, a List of the *Poor* in your Neighbourhood (page 75).

You must not think of making the *Good* you do, a pouring of Water into a Pump, to draw out something for your selves (page 78).

Do Good unto those Neighbours, who will *Speak Ill* of you, after you have done it (page 80).

Often mention the Condition of the *Poor,* in your Conversation with the *Rich* (page 100).

The *Wind* feeds no body, yet it may turn the *Mill,* which will grind the *Corn,* that may Feed the *Poor* (page 101).

To *Bear Evil* is to *Do Good* (page 103).

One Small Man, thus *Nicking the Time* for it, may do wonders (page 179)!

At a very early period in his life Franklin had acquired a great mastery of language, and an excellent style in writing. It was clear and terse, and left no doubt as to the meaning he intended to convey. This high art is rare, and more easily recognized than described. In many ways it is the man himself, and shows him off from every point of view. It is never learned by rote, but comes largely by practice, and also by familiarity with the works of good writers. Franklin was a close reader, and in his boyhood devoured everything in the shape of a book within the reach of his limited means. He studied Locke's *Essay on the Human Understanding,*— a work to which many a man has acknowledged a debt of gratitude for its help in mental training. He had also read Bunyan's *Pilgrim's Progress,* and a stray volume of *The Spectator,* both excellent models for a young man to copy. In one of his Almanacks, Franklin says that Addison's "writings have contributed more to the improvement of the minds of the *British* nation, and polishing their manners, than those of any other *English* pen whatever." While yet a printer's apprentice he wrote articles for his brother's newspaper, the authorship of which was at first unknown to the editor; and he also wrote doggerel rhymes, in those days often called "varses," which he hawked about the streets of Boston and sold for a trifle. In this modest way he earned a few extra shillings and laid the foundation of a brilliant career. Who can say now that his success in after-life was not in some manner connected with the narrow circumstances of the young ballad-maker?

As at that time the drama was not regarded with favor by the good people of Boston, I have often wondered if Franklin in his

boyhood had ever read any of Shakespeare's plays. The original settlers of Massachusetts abhorred playwrights, and looked with distrust upon everything connected with the theatrical stage. Even in his boyhood Franklin had such a keen appreciation of what is great and grand, and such a lively concern for all things human, that it would be of interest now to know that he, too, had paid silent homage at the shrine of the "sweet swan of Avon." In *The New-England Courant* of July 2, 1722, there is a bare allusion to "Shakespear's Works," which is probably the first time that the name of the great dramatist is mentioned in New England literature. It occurs in a list of books made by an anonymous correspondent, as belonging to himself, which would come handy "in writing on Subjects Natural, Moral, and Divine, and in cultivating those which seem the most Barren." The whole communication reads not unlike the effusions of the young printer, and may have been written by him.

The circumstances under which Franklin left home are too well known to be repeated here. Youthful indiscretions can never be defended successfully, but they may be forgotten, or passed over in silence.

From his native town Franklin went to Philadelphia, with no recommendations and an utter stranger; but fortunately before leaving home he had learned to set type. The knowledge of this art gave the friendless boy a self-reliance that proved to be of practical help, and laid the foundation of his future fame. During a long life he never forgot the fact that he was a printer first, and Minister Plenipotentiary from the United States of America to the Court of France afterward; and still later President of the State of Pennsylvania. In his last will and testament he sets forth these distinctive titles in the order given here; and in his own epitaph, which he wrote as a young man, he styles himself simply "Printer." This epitaph is a celebrated bit of literature, quaint and full of figurative expression, and has often been re-printed. It bears a remote resemblance to some lines at the end of a Funeral Elegy on John Foster, a graduate of Harvard College and the pioneer printer of Boston, who died on September 9, 1681. The Elegy was written by Joseph Capen, then a recent graduate of the same institution, and was first published as a broadside. Perhaps the lines suggested to Franklin his own epitaph. As a bright boy with an inquisitive turn of mind, he was familiar with the main incidents in the life of

Foster, who set up the first printing-press in Boston, and was probably the earliest engraver in New England.

After Franklin had become fairly domiciled at his new home in Philadelphia, one of his chief aims was to make himself useful not only to his fellow-artisans, but to the community at large. In divers ways he strove to raise the condition of young men, and to impress upon them the responsibilities of life and the duty they owed to others.

In the year 1732 Franklin began to publish *Poor Richard's Almanack*, which not only put money in his purse but made his name a household word throughout the land. It soon reached a wide circulation, and was kept up by him for twenty-five years. It was largely read by the people of the middle colonies and had great influence over the masses. From every available source he selected shrewd and homely maxims, and scattered them through the pages of the publication. So popular did these sayings become that they were reprinted on sheets, under the title of "The Way to Wealth," and circulated in England as well as in this country, and were even translated into French and sold in the streets of Paris. They are not so highly thought of now as they once were; and the more the pity. The present age likes show and style better than quiet ease and domestic comfort, and is sometimes called the gilded age, to distinguish it from one that is not veneered. The pseudonym of authorship on the title-page of the *Almanack* was Richard Saunders, and in quoting these maxims the public often used the expression, "as Poor Richard says," referring to the pseudonym; and in this way the name of Poor Richard has become inseparably connected with that of Franklin. During the latter part of the seventeenth century there had been printed in London an almanack by Richard Saunders, and Franklin, doubtless, there found the name. In fact his own title-page begins, "Poor Richard improved;" showing that it had some reference to a previous publication.

A curious circumstance, connected with the translation of these proverbs into French, may be worth narrating. The translator found a difficulty in rendering "Poor Richard" into his vernacular tongue, as *Richard* in French means a rich man; and to give a poor rich man as the author of the sayings was an absurdity on the face of it. So the translator compromised by rendering the name of the author as "Bon-homme Richard;" and Paul Jones'

famous ship was so called in honor of the Boston printer and the Philadelphia philosopher.

Franklin never accepted results without carefully examining reasons, and even as a boy was slow to take statements on trust, always wanting to know the why and wherefore of things. By temperament he was a doubter; but in the end such persons make the best believers. Once drive away the mist of unbelief from their minds, and the whole heavens become clear. With the eye of faith they then see what has previously been denied to them. Franklin did not set up for a saint, or pretend to be what he was not; and his friends have never claimed that he was free from human failings. They have always looked with regret at his youthful errors, and would willingly blot them out; but he himself has freely confessed them all. It is on his own testimony alone that the world knows his worst faults. "To err is human, to forgive divine."

Franklin was a voluminous writer on a large variety of subjects, but of all his works the *Autobiography* has been the most widely circulated. This book was first published soon after his death, and has since passed through many editions. It has been translated into numerous languages and been read throughout Christendom, where it has charmed both the old and the young; and the demand for it still continues. For close, compact style and for general interest it has become almost a classic work in the English language. The bibliographical history of the book is somewhat peculiar, and makes a story worth telling.

Presumably an Autobiography, published after the death of the writer, would remain substantially unchanged; but it was not so with Franklin's. At four different times there have appeared in English four versions of the *Autobiography*, each one varying from the others,—though they have not always covered the same period of time,—thus making great and decided changes throughout the book. The explanation of this anomaly may be found in the following statement. The narrative was written at various times and places, and the author has given some of the circumstances under which it was prepared. The first part, coming down to his marriage in the year 1730, was written at Twyford, England, in 1771, while he was visiting at the house of his friend, Dr. Jonathan Shipley, Bishop of Saint Asaph, with whom he was on terms of close intimacy. It was begun for the gratification of his own family, and

intended for them alone; but afterward it took a wider scope, and was then evidently meant for publication. He did not resume work upon it until 1784; but in the meantime the incomplete sketch had been shown to some of his friends, who urged him strongly to go on with it. The second part of these memoirs, written while Franklin was living at Passy, near Paris, is short and made up largely of his ideas on life rather than by the recital of events. When he began this portion of the narrative, he did not have the former part with him, which accounts for a break in the thread of the story. The third part was begun in August, 1788, while Franklin was in Philadelphia, and is brought down to the year 1757. This portion ended the Autobiography, as formerly printed in English. About a year after Franklin's death there was published in Paris a French translation of the first part of the memoirs. It is a little singular that the principal portion of the Autobiography, which was destined to have so great a popularity, should have been printed first in a foreign land and in a foreign tongue; and it has never been satisfactorily explained why this was so, nor is it known with certainty who made the translation from the English into the French.

In 1793, two years after the appearance of the Paris edition, two separate and distinct translations were made from it and published in London,—the one by the Messrs. Robinson, and the other by Mr. J. Parsons. Both editions appeared about the same time; and probably some rivalry between two publishing firms was at the bottom of it. They were English translations from a French translation of the original English; and yet, with the drawback of all these changes, the book has proved to be as charming as a novel.

In 1818 William Temple Franklin, while editing his grandfather's works, brought out another edition of the *Autobiography*, which seemed to have the mark of genuineness; and for half a century this version was the accepted one. But in 1868 even this edition had to yield to a fourth version, which gave the *ipsissima verba* of the great philosopher. During that year another edition was published from Franklin's original manuscript, which a short time previously had fallen into the hands of the Hon. John Bigelow, while he was United States Minister at the French Court; and by him it was carefully and critically annotated. This version now forms the standard edition of the *Autobiography*, and

easily supersedes all former versions. It contains, moreover, six or eight additional pages of printed matter from Franklin's pen, which had never before appeared in English. It is also a curious fact in the history of the book that there are no less than five editions in French, all distinct and different translations.

The limits of this paper will not allow me to follow Franklin in his various wanderings either back to his native town or across the ocean to London, where he worked as a journeyman printer. Nor can I even mention the different projects he devised for improving the condition of all classes of mankind, from the highest to the lowest, and thereby adding to the comforts and pleasures of life. The recollection of his own narrow circumstances during his younger days always prompted him to help others similarly placed; and the famous line of Terence applied to him as truthfully as to any other man of the last century. In brief, it is enough to say that on all occasions and at all times his sympathies were with the people. In the great political contest which really began on the passage of the Stamp Act, and did not end until the Declaration of Peace in 1783, he was from the first on the side of the Colonists, and one of their main supports. During the War of the Revolution he was a venerable man, the senior of General Washington by more than twenty-five years, and the leaders all looked up to him for advice. In such an emergency it is young men for action, but old men for counsel; and on all occasions he was a wise counselor.

Franklin's services in Europe as one of the Commissioners of the United States were as essential to the success of the patriots as those of any military commander at home; and he gave as much time and thought to the public cause, and with as marked results, as if he had led legions of men on the battlefield. The pen is mightier than the sword, and the triumphs of diplomacy are equally important with those of generals who lead armies on to victory.

I regret that the space of time allowed forbids me to dwell, as I should like to do, on Franklin's brilliant career as a philosopher. From early boyhood his inquiring mind had led him to study the lessons of Nature and to learn the hidden meaning of her mysteries. It is easy to understand how, while yet a young man, his youthful imagination became excited over the wonders of the heavens, when the lightning flashed and the thunder pealed; and how he burned to find out the causes of the phenomena. By his

ingenious experiments in the investigation of these matters, and by his brilliant discoveries made before he had reached the middle period of his life, he acquired throughout Europe a reputation as a philosopher; and the results of his labors were widely published in France and Germany, as well as in England. In his memoirs he gives a brief account of the way he was drawn into scientific studies, and how the seed was sown which brought forth the ripened fruit; but the preparation of the soil in which the seed was planted dates back to his childhood, when he was reading Defoe, Mather, and other writers, or even to an earlier period. For a full quarter of a century before the Revolutionary War broke out, he had gained such fame in Europe for his attainments, and was so widely known for his fairness, that, when acting as a diplomatist during the political troubles of the Colonies, great weight was always given to his opinions.

By the help of that subtle power which Franklin's genius first described, audible speech is now conveyed to far distant places, messages are sent instantaneously across the continent and under the seas, and the words of Puck have become a reality:

> "I'll put a girdle round about the earth
> In forty minutes."

Through the aid of this mysterious agency, dwellings and thoroughfares are illuminated, and means of transit multiplied in the streets of crowded cities, where it is made to take the place of the horse; and yet to-day mankind stands only on the threshold of its possibilities.

Whether the career of the practical printer or of the sagacious statesman or of the profound philosopher be considered, Franklin's life was certainly a remarkable one. It would be difficult, if not impossible, to name another man so distinguished in a triple character and so fully equipped in all his parts. By dint of genius alone, he arose to high eminence, and took his place with the great men of the age, where he was easily their peer, and where he maintained his rank until the day of his death.

One of Franklin's early acts, fraught with great benefit to scholarship, was the founding, one hundred and fifty years ago, of the American Philosophical Society, the oldest scientific body in America and one of the oldest in any country,—whose numerous publications, covering a broad variety of subjects and extending

over a period of nearly its whole existence, have won for it a proud eminence, and given it high rank among the learned societies of the world.

On this interesting anniversary it falls to my lot to bring to you the felicitations of the Massachusetts Historical Society, which was founded in Franklin's native town and is the oldest association of its kind in the United States. The younger sister on this occasion sends her warmest greetings, and instructs me to express the hope that the same success and prosperity which have followed your growth during a long life of honor and usefulness may continue to abide with you, undiminished and unabated, for long generations to come.

The President next introduced Chevalier Rousseau d'Happoncourt, K. K. Navy, who presented the congratulations of the Imperial Royal Academy of Vienna to the American Philosophical Society, as follows:

SOCIETATI PHILOSOPHÆ PHILADELPHIENSI, CÆSAREÆ ACADEMIÆ LITTERARVM, VINDOBONENSIS, SODALES S.

Qvanti philosophiam qvam merito Cicero omnivm bonarvm artivm procreatricem et qvasi parentem esse dixit maiores vestri æstimaverint ex eo colligitvr qvod iam ante hos annos centvm et qvinqvaginta Beniamin Franklinio dvce et avspice illam qvæ nvnc vestris consiliis regitvr societatem condidervnt ad eam disciplinam excolendam et promovendam. Probe enim intellexerant singvlorvm hominvm doctorvm operam angvstis finibvs circvmscriptam esse iis avtem in vnvm corpvs conivnctis id effici vt lativs propagentvr stvdia ac permvltorvm animi ad satvs illos felicissimos excipiendos præparentvr. Ab his igitvr profecta initiis societas vestra non solvm de philosophia excolenda egregie mervit sed totam de rervm natvra doctrinam præclaris et laboriosis libris illvstravit lingvarvmqve mvltarvm origines et rationes feliciter indagavit atqve diligenter explanavit. Merito igitvr diem qvem vtpote natalem societatis vestræ vno et dimidio sæcvlo svmmo cvm honore peracto sollemniter agitis vobiscvm celebramvs congratvlantes optimisqve votis vos atqve institvtvm vestrvm proseqventes. Firmissimo enim vobiscvm conivncti svmvs vincvlo pio litterarvm amore et svmmo stvdio iis

enixe cvltis omnivm hominvm salvtis promovendæ. Valete viri doctissimi nobisqve favete.

Dabamvs VINDOBONÆ Die iii, Mensis Mai,
Anni MDCCCLXXXXIII.

C. SUESS,
Cæs. Acad. Litt. Vindob., Totivs A Commentariis.

A. ARNETT,
Cæs. Acad. Litt. Vindob., Præses.

Reading the same to the meeting in German, as follows:

DIE MITGLIEDER DER K. UND K. AKADEMIE DER WISSENSCHAFTEN IN WIEN AN DIE PHILOSOPHISCHE GESELLSCHAFT IN PHILADELPHIA:

Wie sehr Euere Vorfahren die Philosophie gepflegt haben, von welcher Cicero sagt, dass sie Mutter und Amme aller Wissenschaft ist, folgt daraus, dass Euer gelehrtes Wirken schon vor 150 Jahren von Benjamin Franklin eingeleitet und seither durch Euch fortgesetzt wurde. Euere Vorfahren haben erkannt, dass auf dem Gebiete der Wissenschaft der Arbeit des Einzelnen enge Schranken gesetzt sind, dass aber eine Vereinigung mächtig zur Erzielung und Förderung des menschlichen Geistes beiträgt. In dieser Erkenntniss ist Euere Gesellschaft entstanden, welche nicht allein das Studium der Philosophie gefördert, sondern auch die Naturwissenschaften durch gründliche und vorzügliche Werke bereichert und Ursprung und Zusammenhang vieler Sprachen durch fleissige Arbeit glücklich gefunden hat. Wir fühlen uns daher gedrängt, die 150. Wiederkehr des Gründungstages Euerer Gesellschaft feierlich mit Euch zu begehen und beglückwünschen Euch und Euere so herrlich fortgeschrittene Anstalt. Wir sind mit Euch verbunden durch das gemeinsame Band der Liebe zur Wissenschaft, welche das Wohl der Menschheit in hohem Masse gefördert hat.

Lebet wohl und behaltet uns in Euerer Gunst.

SUESS,
Secretär.

ARNETT,
Präsident.

WIEN, 3. Mai, 1893.

Also a translation of the same made by himself, as follows:

THE MEMBERS OF THE IMPERIAL AND ROYAL ACADEMY OF SCIENCES IN VIENNA TO THE AMERICAN PHILOSOPHICAL SOCIETY, GREETING:

How much your predecessors cultivated philosophy, of which Cicero says that it "is the mother and nurse of all sciences," is shown by the fact that, so far back as 150 years ago, Benjamin Franklin introduced the study, which has since then been continued by you. Your predecessors recognized that in the domain of science narrow bounds are set to the pursuit of individuals, but a union becomes mighty in gathering and furthering what concerns the human mind. Recognizing this fact has your study arisen, which not alone encouraged the study of philosophy, but of the natural sciences as well, and by original publications, discussions and collections prove your active work.

We feel ourselves therefore called upon to join with you in the celebration of your One Hundred and Fiftieth Anniversary, and congratulate you and yours upon your grand progressive institution.

We are connected with you by the common bonds of love for knowledge, which has in a great measure helped the welfare of humanity.

Farewell, and keep us in your memory.

SUESS,
Secretary.

ARNETT,
President.

VIENNA, May 3, 1893.

The President next introduced Prof. J. M. Hoppin, who read to the Society an address on "The Philosophy of Art."

The subject of the paper which I have the honor to present is "The Philosophy of Art," and as this would seem to be in accord with the object of your venerable Society, devoted to philosophic inquiries, as well as in the line of my own pursuits, I have presumed on its fitness for this occasion. And, might I be allowed also to say, that the present is a favorable time to discuss art while we are having the great Exposition in which art holds so conspicuous a

place. In looking at the buildings erected on the Fair grounds, at Chicago, I could not but think that architecture, at least, would receive a vigorous impulse in our land; for in these buildings there is an originality, a sense of creative power, a pregnant suggestion of something new, of a style more truly American than that of the Middle Ages and better suited to express the breadth and simplicity of our democratic ideas, which will doubtless be worked out by American genius into a national architecture of noble design, of which we need not be ashamed and can claim as our own. But my object at present is purely theoretic rather than practical. It will dwell more on the idea than on the expression of art.

The subject of the philosophy of art may be still more briefly comprehended in the term "Æsthetics." Æsthetics, from a Greek word of subtle meaning, was first used comparatively recently in Germany to signify the philosophic classification of those mental faculties with which we perceive and are pleasurably affected by the beauty of the world, and was thus made to comprise more than the term fairly means, viz., the whole theory, production and criticism of art; and yet this word, "æsthetics," happily emphasizes one important element of art—feeling, or the sense of delight in the perception of beauty—for art springs chiefly from the emotions and love, just as in the "terribleness" of Michael Angelo's nature averse to delights there was one spring of joy—the love of his art and beauty; and so, too, after the influence of the skeptical philosophy of the early part of the eighteenth century, that dried up the spiritual emotions, the new feeling for the beautiful opened by the movement of romantic literature, produced such works as *Faust* and *Wallenstein*.

The philosopher, Hegel, in treating æsthetics as a branch of psychology, set to work to explore the laws of spirit which constitute mind and to construe nature and art by means of universal ideas, on the principle assumed by the German transcendental philosophy of the subjectivity of all knowledge, regarding nature as the unconscious realization of spirit in time and space, and, in the same way, viewing the genesis of every human institution, science and art as spiritual expressions. He sought to trace through its various stages the philosophy of culture, and to develop *a priori* the history of human consciousness in its growth from the first crude ideas to the

most advanced theories that shape our modern civilization. Civilization, in his application of philosophic analysis, is the mind realizing itself. Human consciousness perceives the ideal form which measures and moulds the phenomenal world, although this consciousness is not awaked at once, and only gradually awakes to find itself contemplating its ideal prototype, its absolute personality, which thus becomes self-consciousness; and this rousing of self-consciousness constitutes the intellectual progress of the race. It sees its ideas realized, or reflected, in art as well as nature, and makes at each step an advance in civilization. Hegel's philosophy was the revelation, in the world of time and space, of self-consciousness, of the personality of the absolute, of the advancement of humanity in the consciousness of its unity and perfection, of the gradual merging of the individual into the universal, which universal consciousness is the progress of thought from nature to spirit, from the sensual to the ideal, from the objective to the subjective; and, under this system, art is an expression of the spiritual, a manifestation, more or less clear, of the eternal idea which measures the outer and phenomenal, recognizing in the external world the image of itself and comparing all things to this inner form, this self-determined and abiding idea, which is the absolute, the ego, the rational totality of the race, the spiritual personality. The reality of things—art among them—is in the idea, while all else is show and changing phenomena. "The real world," says an Hegelian writer, "is the spiritual world; things exist because spirits experience them, and spirits experience them because, as parts of the complete life, it is their interest to be as manifold and wealthy in their self-realization as possible."

In a word, idealism, in which the world of nature and art is the evolution of spiritual existence—this is the basis, the road-bed, so to speak, in which Hegel's æsthetics is planted; and it must be confessed that it is an admirable foundation of art, going beneath the superficial theories now prevailing, most of which regard art as a mere fashion to catch, like a mirror, the flitting reflections of the outward, and to decorate life and amuse the senses; and also going beneath that false realism which lies in the physical merely, and not in the mind that contains the unchangeable types of beauty. Art, according to Hegel, is the discovery of the type-ideas upon which nature and all things are formed and which must be sought within, not without, so that self-apprehension is the artist's highest law,

and that by which he seizes the universal, the absolute beauty. Nature acts as a medium of the manifestation of the ideas, or idea, of beauty, and is the objective form of a subjective fact. The artist studies nature, viewing it as an intermediary of the spiritual perfect truth, and not as perfect in itself; for perfection is in the idea consciously apprehended.

Mr. Stillman, in a recent article in the *Atlantic Monthly*, entitled "The Revival of Art," has favored this Hegelian theory of art, carrying it, however, so far as to make the artist wholly an idealist inspired by that beauty which he sees in his mind, and he seems to give but little value to the inspiration and study of nature, quoting Turner's saying that "nature puts him out."

The truth, I believe, would hold nature as that which mediates between and unites the ideal and the real, the subjective and the objective. The true idealist is he who has the deepest knowledge of nature, and who can use this knowledge in the formulation of his own conceptions.

But, even before Hegel, Schelling attempted to construct an æsthetic philosophy. His poetic temperament led him to look on nature as unconscious art, and to believe that material forms symbolize spiritual processes, so that in nature our ideals are expressed. He said that "artists were often unconscious philosophers and that the greatest philosophers were consummate artists."

Singularly enough, too, the pessimistic philosopher, Schopenhauer, set forth one of the most consistent, if but partial, theories of æsthetics of any of the school of the German idealists; for while himself belonging to this school, instead of Hegel's ego, or spiritual personality representing the absolute, he regarded the "world-will," or the concentrated power of all world-activities, as the capricious and accidental but real creator of the phenomenal world of nature, which "world-will" and its ideas we interpret by experience. Our intelligence, as also a creature of the *Weltgeist* or *Weltwille*, penetrates to the inner will of nature, and "reaches its perfection in the power of contemplation that sinks into the depths of nature, and which belongs, above all, to the temperament of the productive artist." Art, then, according to Schopenhauer, is "the embodiment of the essence of the 'world-will,' as seen or interpreted, by the artist's intelligence. The world-will has fashions of expressing itself, kinds and degrees of self-objectification, and these, in so far as contemplation can seize them, are ultimate types or

ideas exemplified in space and time by individual objects." They are the embodiments of the world's desire, of the world's passion and longing, the forms of the whole world's will that exist. Art grasps these world-forms, these types of creation, action and desire, and exhibits them in artistic forms; for an example, architecture (as a commentator of this philosophy says) "portrays the blind nature-forces or longings of weight and resistance;" or, as I venture to add, the harmonious arrangement of matter and mass, paralleled by the scientific theory of the rhythmical disposal of molecular atoms. Art is the universal appreciation of the essence of the "world-will" from the point of view of an intelligent onlooker, above all, artist; and thus art, while embodying the world's desire or will, is not itself the victim of passion. Of all the arts, according to Schopenhauer, "music most universally and many-sidedly portrays the essence of the world-will, the soul of desire, the heart of this passionate, world-making, incomprehensible inner nature;" and listening to the longing and oft abrupt strains of Wagner's music, I have been sometimes startlingly reminded of Schopenhauer's "world-will," or desire, so wistful, passionate, objectless and chaotic, and finding its utterance in those weird and changeful harmonies. "The opposition between will and contemplation" reaches, indeed, its most systematic statement in the philosophy of Schopenhauer; but the difficulty remains that the "world-will" of Schopenhauer is at best "a simple desire and selfish striving," and the longing after perfection even is only an accidental and changing will, whereas human life has a spiritual centre (ψῦχή), as the material universe has a physical centre, from which ever-recurring influences and attractions spring, that tend to the recognition of unchangeable and eternal ideas of beauty—a will lying back of the phenomenal world in the spiritual; and in this Hegel is truer in his æsthetic philosophy than Schopenhauer.

Leaving these speculations of the German idealists, let me offer some thoughts, imperfect though they may be, on the philosophy of art as a good theme to theorize upon, and tending to promote the best interests of art, which is assuming, together with physical science and literature, its own great place in modern civilization as well as in modern education; and suffer me to follow out here for a moment this suggestion in regard to education. It might be taken for granted that the training of the knowing powers makes education mean nothing unless it mean the development of the

intellectual faculties; but this surely is not all in education. There is left a portion of the being which is more peculiarly the region of æsthetic power, and in which are the sources of the beautiful; and how broad a region and how narrow the view which would suffer this part of our nature, the truly human part, to lie barren! It is the æsthetic power that reconstructs and makes all new; it is the creative power. It is that which gives one man's speech a freshness that another's of equal force of thought does not possess. Æsthetic culture should be introduced into education also, because art comprises so great a portion of the life of mind. It needed mind to build St. Peter's dome and to compose the music of Sebastian Bach, as truly as to compose the *Principia* or the *Mechanique Celeste;* and we are not confined to architects, musicians, painters and sculptors, but may reckon in as artists the poets who body forth ideas of beauty reflecting spiritual types. It is the province, too, of education to bring out the lovely perfection of truth, so that it shall meet the desires of the mind and be followed freely; yet as a people we have freedom much on our tongue, but not so much in our spirit. We have brought down everything to the dead level of the actual. It is the thing which answers the present use, the present success, and not the thing which should be, or the ideal; and while we would not weaken this noble, practical, American quality, we would counteract its current towards an utterly earthly conception of life and thought; and art would help in this struggle to deliver ourselves from the crass bondage of materialism and to give play to spiritual ideas. Art would likewise afford a counterpoise to certain narrowing tendencies in education by presenting truth in more natural and vital forms. The purely scientific process, it is true, comes first. The mind must learn to investigate and reason. First fact, then beauty. But the scientific process has its dangers unless guarded against, dealing as it does almost entirely with analysis, and may tend to lose the living synthesis of truth, and not to come, after all, to the unity of knowledge and the perfection of truth. Art through its intuition arrives often at truth's wholeness when science sees but in part. Art aims at unity, the beautiful whole, the perfect form of nature and spirit, and its influence is towards the introduction of a living variety into educational processes, so that young men may come out of the university not mere scholars, but men of broad, alert and independent minds, with the

eye open to see the beauty and glory of the universe. But to return from this digression.

We sometimes hear it said that man is a religious animal, and yet it might just as well be said that man is an artistic animal—artistic in the constitution of his mind. Metaphysicians commonly divide mental faculties into reason, sensibility and will. This metaphysics —whose tendency is to view mind by sections, as it were, or as a congeries of faculties, each distinct from each, and which assigns its own value to different powers, giving to some an undue value—is apt to make the so-called intellectual faculty an exclusive object of consideration, losing sight of the truth that the mind is one and indivisible, that it acts as a whole, and that, in every act, all its energies enter, some more and some less; that there is a vital interplay of functions in mental acts, intellect in feeling and feeling in intellect, the rational nature resting on the moral and the moral moved to activity and choice by the sensibilities and imagination, so that, however convenient this metaphysical classification may be for the analysis and study of philosophical concepts, you cannot erect such distinctions in the inner spiritual substance of the mind, and to do this sometimes leads to grave errors; for you cannot really say that any one part of the mind is of more value than another and that any part of the mind can be ignored, or affirm that it does not belong to mind as mind, and therefore deserves no special attention. Shall we neglect that rich domain where lie the springs of feeling for the beautiful, the productive powers in the achievements of art? In this realm, called, in metaphysical language, the sensibility, is found mainly the domain of art, though it is by no means confined to this, since all the faculties are involved in art—reason, invention, will, the use of the intellectual and logical faculty that pervades a work of art, the judgment as well as feeling. But there is, nevertheless, a quality of sensibility, of emotional susceptivity, which is the mind's power of receiving impressions from the outward world and its beauty. This feeling is not a mere excitation of the senses, the sensual nature, but it is a mental susceptibility which not only feels but acts, and, when roused to act by impressions from objects, it becomes a power of self-differentiation, or a power of contemplating itself, a power capable of recognizing its own acts and impressions made on it, and of reproducing these impressions, being the correspondent within to the nature without; and it is thus a permanent quality, to which we give,

with other elements combined, the name of *the æsthetic sense,* or, from the faculty through which this instinct chiefly operates, the perception or sense of the imagination. The imagination is the idealizing, the image-making power—the power that receives and communicates the form of things (*form-sinn,* as the Germans name it), even as the intellectual faculty receives and communicates the truth of things. This æsthetic power of the imagination, when acted upon by correspondent objects in nature that are sympathetic to man's spiritual conditions, seeks to reproduce the essential form of these objects, since they exist in the mind only in their forms—some philosophers deny any other real existence to objective matter—and on seeking thus to reproduce the forms of things, by a law of the mind it strives to reproduce the perfect form in which the mind delights and was made to delight. The mind's susceptibility to be impressed by the world of nature through the organ of the imagination, which not only receives but imparts impressions of objects, since it is full of energy and creative power, is the mind's function of form, and, necessarily, in a rational nature, of perfect form or beauty, and here dwell the ideas of beauty in the mind. If the imagination works simply in order to body forth the form of things as an "idealized imitation," to interpret nature in all its forms, it works artistically and its products are what are termed "art." The artist, in fact, is the poet; he is poet of another sort, who tells in line, form and color, as the poet in words, what nature tells him; and this is the more important because we ourselves are parts of this nature, inframed in her subtle organism. The artist, by his imaginative or *quasi* creative power, reconstructs nature, becomes nature's interpreter, and finds in nature the responsive image of the soul. Art is poetry, mainly poetry—I believe this.

We see thus in all mind, though in a less degree in most men, but especially, and sometimes supremely, in the artist, this æsthetic power, this artistic faculty, by which it must and will express itself in the sphere of art as surely as the mind must and will express itself in the sphere of knowledge, and, indeed, so related are the mental powers that, as we cannot keep out any of them from the æsthetic faculty, so we cannot keep out the æsthetic sense from any of these, and we cannot say—in the investigation of truth, the highest truth, which is moral—that the imagination, which is the organ of the sensibility, can be excluded, for here dwell the forms of truth and beauty. I am a Platonist. I believe art belongs to

the spiritual powers, and is, in some sense, spontaneous—a law to itself. Schiller says: "The artist (meaning the poet or creator) is no doubt the son of his time. But ill is it for him if he be also its pupil or darling. A beneficent divinity snatches the suckling in time from his mother's breast, nourishes him on the milk of a better age and lets him ripen under distant Grecian heavens to his maturity. Then, when he has grown into manhood, he returns to his own country in the image of a stranger, not always to please it by his presence, but, terrible as the son of Agamemnon, to purify it. The substance of his work he will take from the present, but the form of it from a nobler time, yea, from beyond all time, out of the essential, invariable individuality of his own being." *

The highest conception of art is that it is the interpretation of the spirit in its varied forms, feelings and experiences, and of those eternal ideas of beauty that are in the soul and belong to absolute mind; but this admits, of course, of modification when other faculties and qualities of our nature—above all, the sensuous—come into view. The senses play their part in art, and a great deal of art is on this lower and not unnatural plane. What a world, that of color! Color has a strong, sensuous appeal, as in nature, but is sometimes too pronounced in art, as in the luxurious warmth of Rubens, the fiery tones of Raphael's greatest pupil, Giulio Romano, the violent contrasts of the Spanish school of painters.

Now to discuss this subject in a direct manner, What is art? But we can only approximate to a definition. It is impossible to give a rigid definition of art. It bursts from our formulas like an uncontrolled spring. It is indefinable because it is a truth rather than a term; and yet we may do something towards a definition by separating art from truths closely akin to it. Art, for example, is not nature, while it is nothing without nature, as Shakespeare says:

> "There is an art
> Which doth mend nature—change it rather, but
> The art itself is nature."

Nature, in a general way, is all that is not art—all that is created, not made. Nature is the substance, physical and spiritual, out of whose depths art arises like an exhalation of beauty. It comprises the forces at work to produce the phenomena of the world and their laws outside of human agency. Those phenomena in ourselves

* *Æsthetic Education of Mankind* (ninth letter).

and the world "which we do not originate but find" represent nature; those "which we do not find but originate" represent art. Thus the human element comes into art to mold nature to its purposes. Art, too, is not science. Science concerns itself with knowledge and the investigation of truth, and it may be said to be the law of knowing, dealing with the facts of the universe, its chief instrument being the reason whose special function is analysis. Art has also to do with knowledge, and art may aid in the search of truth; but it does not end in knowing. Art is, in fact, a science as far as its methods of *technique* are concerned, and it applies science to its own methods, but its end is farther on in the perfect and joy-giving work touching profounder emotions, rather than in scientific knowledge or the technical process. Art, in like manner, is not philosophy, nor religion, nor morality; and it does not pretend to overtop, oppose, usurp or meddle with these while keeping to its own sphere, and much confusion has been caused (and no one has done more of this than Mr. Ruskin) by mixing these; but the difference in such cases is obvious. Art, however, is no negative thing, but is a most positive reality, in that it implies the existence of natural material on which to work and out of which to create its results, requiring at the same time a principle of susceptive thought that understands and orders nature for its conscious ends. In every work of art, its original material of nature, the subjective idea which calls it forth, and the form which is complete in itself like a divine creation, are comprehended. This applies to all forms of art, even the most mechanical; and, first, the term doubtless meant the arts of bare existence, first of all, probably, the art of agriculture—the "coarse arts" as Emerson called them in contradistinction to the "fine arts"—so that the useful was the first idea, and, indeed, what is not intrinsically useful is worthless now in art, in the highest art, which belongs to the highest needs of being, and compared with which its commoner uses are as earth and clay. But as new methods of civilization arose, art came up into its more spiritual spheres. Nature was studied; her subtle laws of working were lovingly observed; finer natures were touched to finer issues; and the arts which have in them a thoughtful element, which spring from an idea, succeeded the arts of mere existence, until "art" won a peculiar meaning, limited to the production which has in it the love of perfect creation, of beauty, which Plato says is the most

manifest and desirable of things. But while the artist represents the beautiful object that he sees in his mind's eye, and paints from this mental image, art is never simply a mental act. Hegel contended for this. Art, without the mediation of objective form, he said, was an empty thing. "The art-idea is not a mere conception —'*ist niemals ein Begriff*'—inasmuch as the latter is a frame into which different phenomena may fit, whereas the artistic idea must stand in the most intimate agreement with the particular form of the work." The subject must be conceived in the object; there must be the manifestation of the idea, which is its expression, as in nature, and which expression must accompany the conception. Expression, in fine, reveals the artist and is another word for his art; for if it be true that

> "Many are the poets sown by nature,
> Yet wanting the accomplishment of verse,"

it can hardly be said that the power of vision in the artist is ever unaccompanied by the power of expression, though the two may be unequally distributed. The bas reliefs on the pediment of the temple of Zeus, at Olympia, which Pausanias ascribes to the Attic sculptors, Alkamenes and Paionios, are conceived with the utmost dramatic power, but are stiffly and rudely executed; probably the conception was that of the great artist and the work that of the local artist. What wonderful power of expression, for another example, is in Rembrandt's painting of "Abraham's Sacrifice," now in the Hermitage, at St. Petersburg—the obedience of a servant, the heart-rending grief of a father, the mysterious awe which the celestial messenger inspires! Here the great artist is seen, and great artists exist because they cannot help being so any more than the roots of a willow-tree can help running to the water. Da Vinci and Correggio were predestined artists as truly as Isaiah and Martin Luther were predestined prophets and Dante and Tennyson predestined poets; for the spiritual conceptions and yearnings in them, the strivings for universal beauty, found their only expression in art-forms.

Art, therefore, if we should attempt to define the indefinable, might at least be described in its works as the power of representing, like a new creation, in form, line and color, the object presented to the mind, or, more specifically, to the imagination, which is awakened to act by a joyful and loving sympathy with nature in

all her forms—it may be ugly as well as beautiful—but more especially with what is beautiful and perfect in nature, as that for which the mind was originally made or adapted.

1. Art, though having to do with the perceptive faculties and the senses, is spiritual in its essence and has its foundation in an inner susceptibility of the soul, which corresponds to outward forms. There is a power in the mind of receiving impressions corresponding to the power that impresses. There is more than this. The mind contains the very ideas, in their conceptual mold, in which the forms of natural objects are cast, and is fitted to comprehend them, so that art is the condition under which the sensibility for impression is excited when the object and subject become identified. The German philosopher, Lotze, indeed says that "the impression of beauty cannot be referred to a uniform standard in us, to a spiritual organization actually existing in all individuals, but to one that has first to be realized in each person by means of development, and realized in each only in an imperfect and one-sided way;" but, though this opinion of Lotze's may be true, that the perfect standard is not realized in every mind, or in the artist himself, yet for it to be realized at all, there must be the organization, the susceptibility in every mind as mind, and the imperfection of its development does not militate against the truth that there is an ideal condition, like the plate delicately prepared to receive impressions of objects, and without which the actualization of any form of beauty would be lost and objects would remain without form and void. A mountain is a pile of rocky matter of a certain geologic period, as science teaches, until thoughts of majesty, unity, power, are developed in its impingement on the ideal sense. The beauty of nature is only to him who appreciates it; but we are all of us inframed in this natural kosmos as an organism itself designed to be that through which the soul realizes its ideas, and without which the mind could not formulate them, and this is the most important part nature plays in art. In like manner the ethical sense is a permanent condition of the soul, but the ideas of justice, right, duty, are not developed except in the actual relations of our natural life.

Call the beautiful an intuition or not, man, I contend, has an æsthetic sense, the outcome of whose formulated ideas is art, and which is capable of recognizing and expressing the objective view and beauty of the universe. We are subjects of impressions which

do not always find expression, and only do so when they impress with sufficient power to form distinct conceptions. We may feign an appreciation and enjoyment of nature that we do not feel. There is an æsthetic cant as nauseating as any other cant. The first hunter who saw Niagara was doubtless overpowered by its terrorizing sublimity, but, it may be, his uncultured mind soon recovered its ordinary apathy, and he saw nothing in the stupendous phenomenon to give him delight, and made his preparations to cook his dinner on the edge of the cataract as coolly as ever. With an Audubon it would have been different.

> "If the eye had not been sunny
> How could it look upon the sun?"

I have, however, guarded against the theory that art exists solely in the mind, solely in the idea, and that there is no intrinsic beauty in natural objects but what the mind creates in them.

2. Art is the interpretation of the significance and beauty of nature. The product of the subjective capacity when drawn forth by the beauty of nature becomes the language of art. Some think of nature only for scientific and practical uses, but "nature," says Canon Mozley, "has two revelations—that of use and that of beauty. The beauty is just as much a part of nature as the use; they are only different aspects of the self-same facts, the usefulness on one side is on the other beauty. The colors of the landscape, the tints of spring and autumn, the lines of twilight and dawn—all that might seem the superfluity of nature—are only her most necessary operations under another view; her ornament is another aspect of her work; and, in the act of laboring as a machine, she also sleeps as a picture. The same lines which serve as the measure of distance to regulate all our motions also make the beauty of perspective." But beyond this idea of Canon Mozley's, it is my belief that there is actual contrivance in nature for an appeal to the æsthetic sense. Mountains that surround a valley "like a chorus of hills," by their fusion of noblest forms with finest tints, speak directly to the mind, as do the powerful words of a chorus in a Greek drama; and there is found also in nature every secret, even the subtlest, for the result of beauty, so as to produce the effect of beauty and power on the mind of the beholder. This is nature's art. What Venetian blue is like the blue of the Rosenlaui glacier? What painting ever excelled the splendors of

> "The fiery noon, and eve's one star?"

He who begins to study nature, who observes trees or a single leaf, who looks closely at the minute grass-spires under his feet that cover the whole earth, who notices the tricksy play of light and shadow, who watches the sky, "sometimes gentle, sometimes capricious, sometimes awful, never the same for two moments together, almost human in its passions, almost spiritual in its tenderness, almost divine in its infinity," he must believe that there is in nature that which is designed to convey thoughts to the human soul beyond those of mere sense. Art interprets this higher truth. "The aim of art," says Taine, "is to manifest the essence of things." Art, indeed, seeks for the means of the highest effects. It depends on a penetrative study of nature's principles, and here it still may be original. Here the Yankee artist has as good a chance as the Greek. Here American art may prove its claim to originality as truly as Dutch art has done. The artist, to be an interpreter, must have knowledge, whether gained by study or instinct. He goes lovingly where nature leads him, and enters this kingdom of art by becoming a little child, until, through long discipline and patient watching, he sees "the most essential quality of things;" he grows into such intimacy with nature that he comes to interpret the thoughts of nature and also the thoughts of the human heart. The group of the "Niobe" came out of the profoundest depth of human experience—there is, morally, nothing more suggestive than this sculpture in modern art—as the Greek poet, Meleager, in his poem on the "Niobe," believed and proved this in ancient art. There is a fragment of the Reformation in the works of the satiric, keen-eyed painter, Holbein. There is much of the splendid but corrupt sensuousness of the neo-pagan Renaissance period, under Christian forms of humanity, represented in Titian's voluptuous pictures; for art is a reflection of life and its multiform phases, fascinating or terrible as the ages march on, and of the life of the soul.

3. Art finds its laws and principles primarily in nature. It cannot go a step independently of these and remain art. Michael Angelo seemed to lose his creative power, and virtue went out of him the moment he left nature and began to work from a dry scheme of abstract form.

There is, for instance, the fundamental law of truth, which involves the idea upon which the universe was built. There must be a sensitive relation in the artist's mind to this law, without which art is artifice or sham. But art, as has been said, is not nature, nor

does the artist, in Coleridge's words, "pick nature's pockets." Nature is inimitable; for how can a little square of painted canvas convey the infinitude of mountain scenery whose power is revealed like a divine inspiration? Yet nature in her commoner moods, if still inimitable, is genial and accessible. She is odd and humorous at times, with a fancifulness full of grotesque irony. She does not hide her winsome face. She invites us to sit at her feet and learn of her. She will herself teach us. We cannot follow her instructions too closely, nor imitate her too minutely. Not a leaf but is a map of the boldest and most complicated pattern. Nature furnished the originals of Greek forms of every sort. But the artist must go beneath the surface of things to the plastic laws of these forms, else imitation would be untrue. He must discover, as it were, nature's own law of creation. A picture is an illusion, but it is not a delusion, for its end is not imitation, which would be something unreal and an absurdity, but it is the production of similar effects of nature's beauty and power so as to speak to the mind in some sense as nature speaks. While the artist is not to leave nature and lapse into a dreamland of his own, while he is to seek truth, yet by his thought, by separating the natural object from its accidental circumstances and conceiving it as a whole, by so painting the tree, the flower, the man, that the true form is seen, that the type is brought out in which the properties of the species are developed and in which it is best fitted to discharge the functions for which it was made—this shows the highest skill; for here is the action of the artist's soul which gives to his works the appearance of fresh creations. This is the ideal in art. This is the law of mental selection and probably was coeval with the law of imitation even, and accompanied the earliest art, savage and archaic art, since no art, even the most primitive, could have been entirely imitative.

"In the effort to imitate the human figure the process of thought and sympathy becomes apparent; and where this process of controlling power begins there the ideal in art begins. Whenever this isolated position, or scene, or action of nature is taken, it cannot be truly represented unless by an act of thought it is connected with the whole. The idea, or the whole, to which it belongs as a part, must enter into it and transfuse it."*

Yet be it noted that the ideal does not exist without the real passing into it like a life, even as mind works on facts and molds

* A. S. Murray, *Hist. Gr. Sculpture.*

them, and this might be called "the idealized real." The real is the working basis of the ideal, even as the sculptor puts his thought first into a clay model and works from that. The poetic superstructure is grounded in the soil of the actual. "The beautiful is the real," was the Florentine sculptor Dupré's motto. Imitation is not the object of art, or is, at best, a low idea of it; yet how can a picture or sculpture be too true to nature? Were the best Greek sculptures? You may be sure that it was not the close imitation only in the old familiar story of the grapes that made the birds peck at them, but it was chiefly the truth. It was the real life of natural objects that the artist of poetic genius had caught. It was a picture and not a copy. A portrait—what is it worth if it be not real and rugged as life is; otherwise it would become like the many unauthentic portraits of Columbus—a specimen of what has been called "artistic subjectivity?" This realness is the test of artistic excellence. "The more nearly and truly a picture approaches the exact colors and forms of nature, the greater will be the effect." There is no excuse for false drawing. The healthy tendency of art, then, is to become more and more real, which is in the true line of progress. The vigorous revival of art in the Netherlands in the first half of the seventeenth century, which created the Flemish and Dutch schools, to which the names of Rembrandt, Franz Hals, Terburg, Jan Steen belong, was nothing more than a return to realistic art from the feeble conventionalism of decadent Italian classic art. But rashness in theory makes a one-sided development, and the attitude of the artistic mind should be ever that of a thoughtful receptivity. All great painters have been realistic painters, but that is not all that they were. They painted from an idea. Velazquez, the greatest of artists both in technique and expression, did not paint the architecture of a face, but its character, its character drawn from his creative conception of a man. So art must continue to have in it these two elements of the real and the ideal, or it will run into something analogous to that coarse realism in literature, whose works, viewed as works of art, are only pieces of loose real life, without unity and plan; or, on the other hand, that subjective school of poets illustrated by Dante Gabriel Rossetti, ravishing as it is, but neither of them complete in itself. Art would die out, since some essential quality of life would be lost. It would either drop the element of truth to nature or the element of thought. The canons of universal art must not be

swamped in the turbid deluge of French realism; though in regard to French impressionism, which is the tendency of modern art, when not carried to an absurd extreme, I have a good word, as infusing new life into painting, catching the light and atmosphere of heaven, and promising a true advance in landscape art. But it is well to remember, in this realistic age, that art has a spiritual side allying it with poetry and with the loftiest achievements of the mind, in which the beauty that lives in the idea and in the universal and spiritual is expressed. All true art in every age catches a spark of this unfading glory of the beautiful; and yet I do not say that there is no true art which does not aim so high as this, as witnessed in the hundred forms of unambitious art, the crude but honest efforts of beginners, the drawing which aims only at correct imitation, the pictures of many realistic artists painting nature as it is and not so much in minute detail as in whole true impressions, the graphic illustrations of literature carried to such excellence at the present time, the rich field of decorative design which is mainly scientific—all this is pleasing and laudable and having its genuine place in art, but I speak now of art in its enduring forms, which, like the best poetry, is of "imagination all compact," and must spring from the love and idea of beauty. This innate sensitiveness of the Greek mind to *beauty* made it to differ from Egyptian, Roman, and almost every other national art, and constituted it the standard of art for all time. But the Greek sense of beauty was a thoughtful quality of a thoughtful people; since the sensual, strong in the Greek, was subordinated to the intellectual and moral in this finely attempered race. Its line of beauty was a line of strength. Beauty was another word for perfection. "Beauty with the Greek," says an English writer, "was neither little nor voluptuous; the soul's energies were not relaxed but exalted by its contemplation. The service of beauty was a service comprehending all idealisms in one, demanding the self-effacement of a laborious preparation, the self-restraint of a gradual achievement. They who pitched the goal of their aspiration so high knew that the paths leading up to it were rough, steep and long; they felt that perfect workmanship and perfect taste, being supremely precious, must be supremely difficult as well; *χαλεπὸν τό κᾶλον*, they said, the beautiful is hard to win and hard to keep."* Thus beauty, with the Greeks, was the manifestation of their ideal self-development, the working out of a pro-

* *Westminster Review.*

found principle of culture, and this made their art so noble; and it is this by which, in presence of their serious sculptures, our spirits grow calm, and we feel the truth and moral power of the Greek conception of beauty, raising us above our littleness into a region of higher thought and feeling.

So there are other laws of nature besides truth which enter into art, such, for example, as order, which belongs not only to the structure of the world, but of the mind and its structures; as unity, or that consistency of parts with the whole which gives delight in a beautiful object; as proportion, which is the outcome of a symmetric mind; moderation, which is the continence of conscious spiritual strength; grace, which flows from inward sympathy and freedom; character, or individuality, or expression, so variously named, which, indeed, is much the same as ideality, by which the artist expresses his own thought and personality, and by which also a distinctive spirit of the period and history of the work is stamped on it; and not to mention more of these laws, above all, the great law of form, to which everything in art comes, which is the highest intellectual expression of art, so that sculpture, perhaps, is the purest art manifestation; and it is by studying these laws that we come at the principles of art criticism, and through the ignorance of which there is often shown a want of judgment in matters of art, betokening false standards drawn, it may be, from metaphysics or political economy rather than nature, making to be measures of art productions such qualities as logic, difficulty, cost, prettiness, melodramatic effect, bulk, warm coloring, elaborate though senseless detail—instead of the true and invariable standards of nature, by a return to which through the clear instinct of æsthetic genius lies the only road to reform and advancement.

4. Art in its source is divine. The divine ideal has not been perfectly attained, but ever beckons on like a star. Nature is a projection of divine ideas of beauty into time and space; and the human mind, which could know nothing objectively unless the same existed subjectively in itself, can read these types of beauty, or, as Ruskin calls them, "the eternal canons of loveliness," in its consciousness. Ruskin classes among spiritual ideas typical of divine attributes such purely æsthetic conceptions as unity, perfection, infinity, order, repose, moderation, purity, truth. These are moral as well as æsthetic qualities; and I was greatly pleased to come

across this passage spoken to the students of Johns Hopkins University, from a poetic point of view, by an American poet—poet of the salt-sea marshes—Sidney Lanier: "Cannot one say to the young artist, whether working in stone, in color, in tone, or in character-forms of the novel: So far from dreading that your moral purpose will interfere with your beautiful creation, go forward in the clear conviction that unless you are suffused—soul and body, one might say—with that moral purpose that finds its largest expression in love; that is, the love of all things in their proper relation; unless you are suffused with this love, do not dare to meddle with beauty; in a word, unless you are suffused with true wisdom, goodness and love, abandon the hope that the ages will accept you as an artist." Would that Lanier could have lived longer to have outlived some superficial defects of style, to have chastened his luxuriant imagination, and to have carried out his own noble theory of art!

Thus art has a vital beauty belonging to divine things.

The total sensualization of art characterizing a great deal of our modern art, forgets the truth that, though art lies partly in the sphere of the senses, in which "ideas take their plastic embodiment," it has a spiritual source which makes the artist a priest of the divine. "The artist paints with the brain and not with the hands," said Michael Angelo contrary to Courbet's saying.

The noble young science of archæology, which has made such marvelous progress of late, but which, after all, is the serviceable handmaid of art and not art itself, this science, so helpful to art, so indefatigable in its research, so interested, and rightly, in the orientation of every exhumed stone, and so furiously combative in the claims of space occupied by the orchestra and proscenium of a Greek theatre—notwithstanding its brilliant discoveries, has served imperceptibly and unconsciously to set learning before beauty and thus obscure or render secondary the intrinsic idea of art.

Looking at these four principles, viz., that art has its foundation in an innate spiritual susceptibility which corresponds to outward objects and forms; that art is the interpretation of the idea, beauty and perfection of nature; that art finds its laws primarily in nature; and that art in its source is divine; we may judge somewhat, from these rough pillars, what is the vast scope of art, how it reaches into heaven as well as makes our own thought higher, our life sweeter and this earth lovelier. And when we come to consider further

(which investigation I shall not, however, be able to follow out) the philosophical classification of art, this brings out more clearly its theoretic principles; for each form of art is grounded on a reason in the mental constitution, and depends primarily on the nature of the idea which strives for representation, so that every art has a body, as it were, in which its life freely develops itself, and in no other. The arts of expression by language differ from the arts of expression by form and color, and cannot be combined on the same lines of representation. Sculpture cannot perfect itself in the principles that apply to painting; and a familiar example of this is the beautiful gate of the Baptistry of San Giovanni, in which the sculptor, by trying to unite the plastic and the graphic elements, or not keeping them distinct, fails of the highest effect. Yet the principles of all the arts are, in a measure, interchangeable, just as the laws of construction in architecture, bringing into play such analytic qualities as order, mass and combination, may enter with effect into the composition of a picture and lend it unity of design and firmer tone.

One German writer classifies artistic forms into two—the mathematic and the organic; in this way art appears, as it were, a second nature, which represents and reviews her processes. Mr. Hay, in his *Science of Proportion in Greek Art*, goes so far as to say that "all fundamental beauty of form is derived from the vibrations of the musical chord, and is geometric or harmonic in its development, and cannot fail to be reducible to mathematical law." Rhythmic arts, at least, are governed by mathematical laws like architecture in its form in space, and music in its movement in time; poetry also partakes of this regulated character. On the other hand, the arts which represent life, free life, such as landscape, animal existence, and, above all, forms of human life in historic, *genre*, and portrait painting, and especially in sculpture, come under the class of organic art, which arts are essentially imitative, but at the same time they stand in connection with higher ideas. Yet here, too, it is difficult to draw distinctions. Painting expresses, above all, quality and character; and yet in music there is as truly quality as quantity of sound, character as well as harmony. Colors have a genuine resemblance to tone, and colors form an octave which produces concord or discord, and gives rise to as various sensations. Architecture, which is abstractly geometrical, becomes also highly

expressive of thought, feeling and character, almost as much so as painting and sculpture.

Another classification separates all art into groups of technic, æsthetic and phonetic, the first being those that minister to the primary wants, the second to the æsthetic, and the third to those that express ideas by colors, forms and words—in fact, language. But, actually, no positive limits can be assigned to these varieties as a question of fact, and it is rather a matter of degree than of classification. While it is highly productive of thought to make this effort to classify, and is useful as bringing out more clearly the underlying principles of art, it is evident that a deep-grounded philosophic classification has not as yet been reached.

Dr. John G. Morris, having been next introduced, presented a paper on "The Nature and Design of the Historical Societies of Our Country, and the Invaluable Benefit They Have Conferred on the Community," which is as follows:

No one can reasonably object when a public speaker employs the heaven-inspired language of the Hebrew poet in illustration of a subject altogether secular and historical. In the loftiest strains which his language afforded, he invites all men of religious taste and piety to visit the magnificent house of worship at Jerusalem—to extend their walk around the impregnable walls and their massive abutments—to measure by the eye their height and thickness—to look upon the tall towers and their broad bulwarks—the ponderous gates of brass and all the other external wonders of that wonderful edifice—but the admiring visitor is invited to pass through the gates, and to contemplate the magnificent structures erected around the *sanctuary*, the grandest of all, and then to gaze with rapture on the unsurpassed splendor and ravishing architectural glories of that house of God—and why all this? Not merely to gratify a cultivated taste, but to tell it to the generation following—to write the history of it that subsequent ages might know what had been done by their fathers.

And this is the province of the historian of to-day, as it has been of all preceding times—to verify doubtful facts, to develop and record unwritten events, to correct popular errors, to authenticate dis-

puted dates, to delineate the character, influence and deeds of illustrious men; in a word, "to walk about the towers thereof, to mark well her bulwarks and consider her palaces, that he may tell it to the generations following."

This is the design of all historical societies, and many of them have already contributed much to the consummation of it.

Allow me then, ye men of philosophy, on this auspicious day on which you will hear much of what your ancestors have told to the generations that came after them, and of what you are gathering for the benefit of those who will follow you, to speak of a theme closely allied to that which you cultivate. Philosophy and history are sisters, of whom *history* is the older, for history began in the primæval Eden. They tell us that some ancient writer has said that history is philosophy teaching by example; but history furnished the examples before philosophy or science could utilize them. Macaulay was of the same mind when he says: "History, as it lies at the root of all science, is also the first distinct product of man's spiritual nature; his earliest expression of what can be called thought. Before philosophy can teach by experience . . . . the experience must be gathered and intelligibly recorded." And that's history.

I have thought that it would not be inappropriate on this occasion to present a brief dissertation on "The Nature and Design of the Historical Societies of our Country, and the Invaluable Benefit They Have Conferred upon the Community." Of late years they have contributed marvelously to the illustration of our older history and are constantly piling up much rich material for future writers.

The design of such foundations is not primarily to write history so much as it is to collect, arrange, classify, describe and preserve authentic materials of whatever kinds they may be, out of which history may be written. It is true, societies may publish what an individual or a committee has elaborated, and many local histories and cognate papers or treatises have been thus published, but, after all, the main design is to collect the timber, stone, and everything else out of which the historic edifice is built by the master workman, and this most useful work our principal societies have diligently and successfully performed. They are composed of that class of men whom Bacon designates as "industrious persons who, by an exact and scrupulous diligence and observation, out of monuments, names, words, proverbs, traditions, private records and evidences, frag-

ments of stories, passages of books, ... and the like, do save and recover much from the deluge of time."

A historical society should be a "snapper up of unconsidered trifles, and should not disdain to gather even the bubbles that float on the stream of current history, prizing them as the world will one day prize the gems into which they will be transferred by the magic of time." There are thousands of printed documents of one kind and another which few persons think of saving, but which if preserved and systematically arranged into sets become valuable for reference in a very few years, and this is a kind of work requiring painstaking and patience, rather than the expenditure of much money. The breaking up of private collections is the great opportunity of the historical librarians and members, who should always be on the alert for such chances. No scrap which contains a word or name or date of historic value should be allowed to be destroyed or to be thrown into the rag bag or sold to the gatherer of materials for the paper mill.

Whilst the American antiquarian must necessarily feel deeply concerned in whatever relates to the history of the aborigines of our country, and we all know to what extent that subject has been illustrated, especially in the Government publications, yet it is not the history of the Indians in our respective States that has engaged the special attention of our historical societies—though not entirely overlooked, especially by the societies in the Western and newer States—our main purpose is to rescue from oblivion the history of the first settlers of the country, the manners, habits, opinions, deeds, primitive institutions, the early establishments, their family papers, their schools and churches, parish records or newspapers and books, their roads, their country frolics, their holidays and diversions, their civil and social condition, their town meetings and country fairs, their old family pictures, their great men and noble women in every department of active life. It is literally carrying out the capital motto of the Maine Historical Society, "Antiquitatis monumenta colligere."

It is the province of the societies to collect and safely keep account of all these and of many other things. A historical society need and *should* not collect a library of miscellaneous books, nor spend any money on an ornamental picture gallery or a museum of curiosities which do not illustrate the history of the State. If such objects are donated to the society as decorations, and the society

has room to exhibit them, they must not be refused, especially if with the donation provision is made for their safe keeping; but a general picture or a statuary gallery is a very different thing from a collection of historical portraits or other pictures representing great historical events. Such a collection it is desirable to have. Popular and miscellaneous books as well as most of the illustrated magazines and newspapers and quarterlies and monthlies must be sought for in libraries designed for more general use. A museum of household relics of colonial and Revolutionary times, of old documents, ornaments, dress, weapons, furniture and many other things, such as we have lately had exhibited in Baltimore, will teach more history in an hour than a mere fancy picture gallery, of whatever extent or estimated value, will do in a week.

What a fresh impetus has been given to the study of our national history within the last hundred years! It has been estimated by those capable of forming a correct judgment, that since the organization of the Government in 1789, under the Constitution, more than *two hundred* historical societies have been organized, the greater number of which continue in active existence. Most of them aim at the elucidation of the State or county or town in which they have been formed, and the principal means employed for accomplishing the object has been the collection of historical books, of manuscripts, of museums, of historical memorials—in some instances including the natural history of the region, and the printing of historical documents.

All these collections are rendered accessible to the public, and persons devoted to such studies have every desirable opportunity of gratifying their tastes, and every facility should be afforded. The *red tape* tying the documents should be short and the knot very loose. No student need go far to find everything that has been published concerning his own State, besides numerous valuable documents which have not yet been put in print, and to these he should have free access under liberal limitations. Of what use are such historic treasures to any body if they are to be locked up in a fireproof vault, and the use or exhibition of them environed with discouraging difficulties?

Several of the States, as Maryland and Georgia, and perhaps some others, have made their library rooms or vaults of their State societies, places of deposit of valuable State historical records, at least to some extent, and it would have been well if our own State

of Maryland had adopted that wise precaution long ago. Many precious documents would have been saved which are now irrecoverably lost. This measure, of course, is not necessary where the capitol of the State has fireproof vaults in which such treasures may be safely kept, or where other measures of security are adopted, which is not the case in some State Houses we know.

Some State societies have called the attention of their Legislatures to the propriety of publishing the colonial and other early records, to which they have liberally responded, and a few of them have even gone so far as to send competent agents to Europe to secure copies of old papers or catalogues of them from the record offices. Private munificence, in several instances, has rendered the same service, of which we have a notable example in our own collection in Baltimore, as a gift from George Peabody, to whom we are indebted for other similar favors.

State societies have been established in more than half of the States, and they are designated *State* societies as different from *local* societies, either because they derive support from the State, or from the prominence which they give to the history of the State in their collections and printed contributions. Their place of meeting, their libraries and collections, and the principal seat of their operations are usually at the capital of the State or in the largest city, and hence they are distinguished as *State* societies.

There are some, also, which limit their collections to the *records of the church denominations* of their preference. Some of them have formed denominational libraries, and collections of ecclesiastical relics, manuscripts, pictures, Church journals, synodical proceedings, photographs of their clergy, histories of individual congregations or parishes, busts of some of their distinguished ministers, catechisms, hymn books, catalogues of their schools and colleges, reports of their benevolent and missionary societies, all the writings of their authors in this country, and even the old furniture of the fathers of their Churches. Two of the most notable of these denominational historical societies, embracing all and even more of the specific subjects enumerated, which come within my personal knowledge, are those of the *Moravians* at *Nazareth,* and of the *Lutherans* at *Gettysburg*. There are some other Church historical societies, but they are almost exclusively confined to the collection of books and manuscripts.

How are historical societies in general supported? Some have

endowments or other property from which they draw interest or rent—such as those of Massachusetts, New York, Pennsylvania, and a few others. A few, such as Iowa, Minnesota and Wisconsin, and probably others, have special annual grants from their State Legislatures; a few are provided with apartments in the State capitol rent free, which is to that extent an appropriation, but the majority, I presume, are mainly supported by the membership fee, with occasional special contributions.

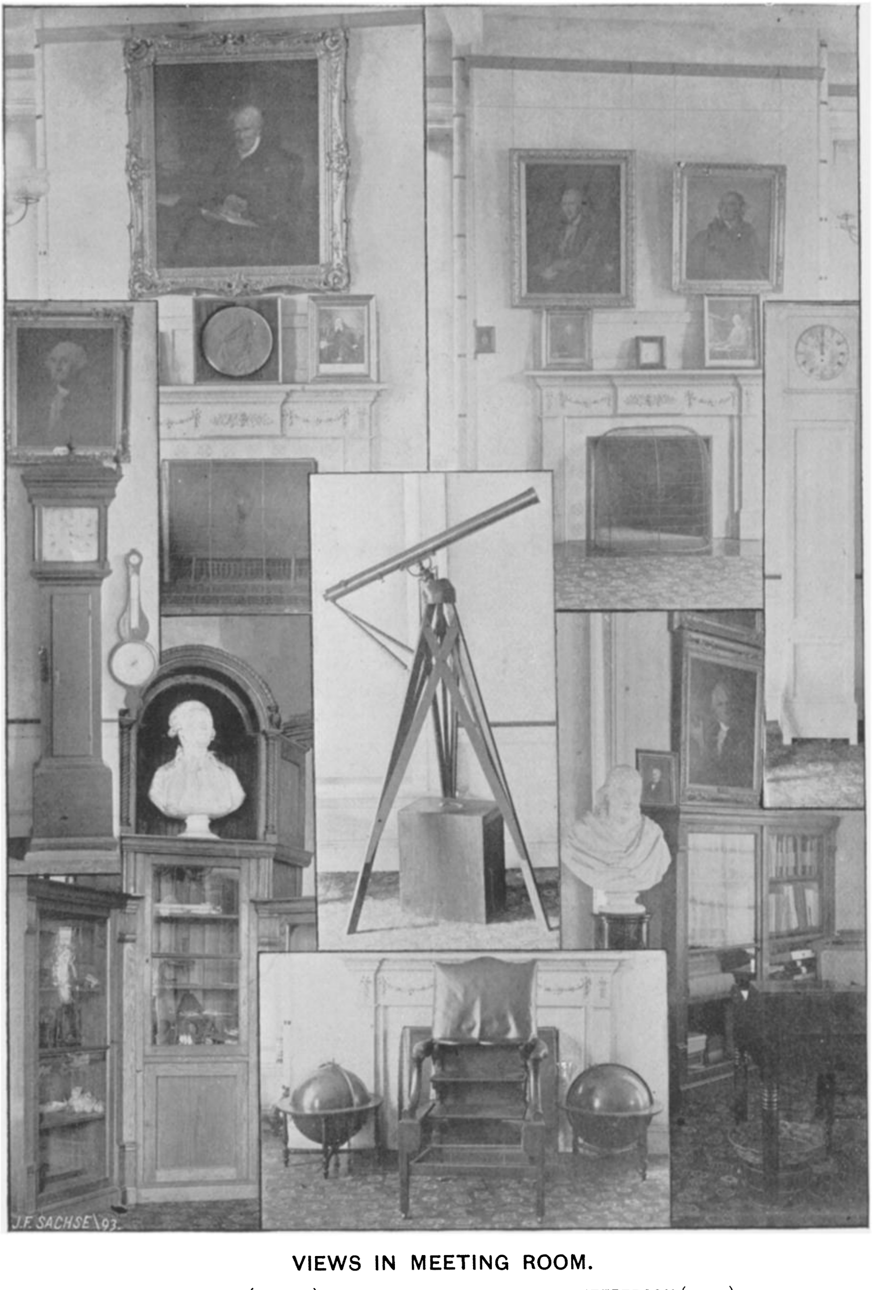
It is natural to presume that American energy would produce important and valuable *results* from such institutions. We, as a people, have never yet failed to bring something good out of material capable of being manipulated. The labors which most of these associations have performed are simply marvelous, and the good they have achieved is worthy of all admiration. Not only have many of them acquired by purchase, or donation, or bequest, splendid edifices, or, at least, most spacious and commodious buildings, in which they have gathered libraries, pamphlets, manuscripts, records, historical relics, museums of State antiquities and other treasures of priceless value, and have saved from destruction historical monographs, biographies and genealogies. They have enriched the literature of history with hundreds of volumes of useful books, containing many rare documents, of which but few knew anything before, but which are now open to all investigators, and many a precious book, which the poor student could not purchase, is now freely laid on the library table whenever he wishes to consult it. They have ransacked old depositories, and have rescued from dust and dampness and destruction many State and family records; they have unearthed many buried treasures of more value than heraldic escutcheons or baronial insignia. They have awakened an interest in historical research before unknown, or at least not concentrated and systematic; they have stimulated the zeal and encouraged the efforts of many a solitary student or obscure investigator; they have fostered the establishment of local and county societies in villages where intelligent persons cannot attend the meetings of the State societies.

But we dare not omit mentioning another result not less important, and that is, the formation of *ladies' societies* with the same general purpose in view. There are now eight or ten societies of Colonial Dames in this country, and although their researches are

confined to the colonial period alone, yet they have done good service. They have not yet published the result of their studies, yet papers have been read, and it is presumed that the public will soon have the benefit of them. These patriotic American women are not out of place when hunting up the musty documents of early American history; their nimble fingers can gather the loose or tangled threads of ante-Revolutionary fragments, and weave them into beautiful historic tapestry.

But it is not only general American history that engages the diligent study of many of these investigators, but there is another branch which, of later years, has gained many ardent votaries, and that is, *family history* or *genealogy*. Old parish records, lists of emigrants, rolls of regiments, rosters of officers, old city directories and almanacs, and every conceivable ancient document that can throw a gleam of light on a family name, a disputed date, a place of residence, a clue to title or rank, is examined with painstaking assiduity. Those of us who have the management of historical libraries receive numerous letters making inquiries into family history. People from far and near want to know all about some relative concerning whom they know little themselves, but presuming that we know all about them, or can easily learn it. The investigation of some cases would require hours of patient labor, and to all excepting such all possible aid should be given.

I have playfully advised some of our resident investigators not to go too far back lest they might encounter ancestors whom they would not like to recognize, and in reply to that a bright lady from a neighboring county observed that she found the farther back she went the better her ancestors became, which pleased her vastly, for she thought some of those not far behind her were no better than they should have been. There are very few who go so far as it is said Dr. Johnson once did, although the same assertion is credited to some others; when he was asked about his ancestors he gruffly replied: "That all he knew about them was, that some of them were hung, and the rest should have been." But it is true that no one not engaged in a historical library can have any conception of the number and character of the people who are inquiring into the history of their forefathers. One fact will show the interest which this subject has awakened. Before the year 1845 the whole number of genealogical societies in New England alone was not over thirty, and twenty years after that there were 400, and since that the number



VIEWS IN MEETING ROOM.

HUMBOLDT (LAMBDIN.)
JEFFERSON (SULLY.)
WASHINGTON (STUART.)
AN ANCIENT TELESCOPE.
DUFFIELD CLOCK, 1768.
RITTENHOUSE CLOCK, 1755.
LAFAYETTE (HOUDON.)
FRANKLIN (MANCONI.)
FRANKLIN'S CHAIR.

has increased in other States also. It has been estimated that over 400 volumes, of 300 pages each, have been published by the various societies, and a much larger number of pamphlets and distinct family monographs.

The genealogies of not a few private families of distinction have been privately published, some of which are sent as donations to our libraries.

The existence of many ancient documents and relics of all other kinds which are locked up in the closets of many private families is shown on the occasion of public exhibitions for the benefit of some laudable object. We had a notable example of this in Baltimore during Easter week. There was a grand display of Revolutionary relics, and yet it is presumed that not half of similar articles existing in the State was sent to that exhibition, and the same may be said of some other States. We all remember what a collection was exhibited in the old State House, in Philadelphia, in 1876, and I believe all those objects were furnished by Pennsylvanians exclusively.

To maintain a historical completeness in this paper, this would be the place to notice the principal historical societies of our country. The number of them is so large, and their history is so extensive, that it would require a volume to describe them, so that not even a beginning can here be made.

Adjourned.

Thursday, May 25—4 to 6 o'clock P.M. Reception by the University of Pennsylvania at the Library Building of the University. In the afternoon the Society and guests attended a reception and garden party, given at Manheim Club House by Charlemagne Tower, Esq.

FRIDAY, May 26, 1893, 11 A.M.

President Fraley introduced Capt. Rousseau D'Happoncourt, who read a paper "On Determination of Gravity by Means of a Pendulum Apparatus," which is as follows:

Die Bestrebungen, die Gestalt der Erde aus den Schwerebestimmungen abzuleiten, sind verhältnismässig neu, sie gehören fast ausschliesslich unserem Jahrhunderte an. Während die Gradmessungen sich allmählich innerhalb 2000 Jahren vom ersten Erkennen der Kugelgestalt der Erde bis zum heutigen Stande der Geodäsie entwickelten, lieferten die Schwerebestimmungen gleich nach ihrem Entstehen ein vollkommen verlässliches Beobachtungs-Materiale zur Bestimmung der gesuchten Erdgestalt, denn es standen denselben bereits die hochentwickelten Theorien der Geodäsie hilfreich zur Seite.

So kommt es denn auch, dass wir heute am Schlusse desselben Jahrhunderts, bei dem Studium über die Schwere auf der Erde, das am Anfange dieses Jahrhunderts geschaffene Materiale noch verwenden können, ja sogar fast ausschliesslich verwenden müssen, da ein neueres Materiale nur spärlich vorhanden ist, und dieses nicht immer das alte an Güte und Verlässlichkeit übertrifft.

Wir können in dem Bestreben, die Schwerebestimmungen der Geodäsie nutzbar zu machen, zwei Perioden: eine am Anfange und eine am Ende unseres Jahrhunderts, unterscheiden. Dieselben sind durch eine lange Pause von einander getrennt, während welcher nichts oder nur sehr wenig Brauchbares geleistet wurde.

In die erste Periode fallen jene zahlreichen vorzüglichen Schwerebestimmungen, welchen wir zum grössten Theile unser heutiges Wissen über die Erdgestalt, wie dieselbe aus Schwerebestimmungen sich ergibt, verdanken, und welche uns auch über die Vertheilung der Schwere auf der Erde überhaupt Aufschluss geben.

Die Namen jener Männer, welche dieses wichtige und werthvolle Materiale der Wissenschaft geliefert haben, sind wohl Allen geläufig.

Mit den grundlegenden Arbeiten Bessel's findet diese fruchtbare Periode ihren, man kann sagen plötzlichen Abschluss.

Erst durch die europäische Gradmessung, jetzt internationale Erdmessung, welche die Schwerebestimmungen in ihr Programm

KARL CHEVELIER ROUSSEAU D'HAPPONCOURT.

aufgenommen hat, entwickelte sich die zweite Periode dieser Arbeiten, in welcher wir uns eben befinden.

Wenn in Europa im Anfange dieser Periode die neueren Schweremessungen nur wenig gute Resultate lieferten, welche jenen der ersten Periode bezüglich der Genauigkeit nachstehen, so hatte dies seinen Grund darin, dass man glaubte, die so verlässlichen relativen Bestimmungen durch absolute ersetzen zu können. Mögen jedoch die absoluten Messungen noch so genau ausgeführt werden, immer haften denselben mehr, und meist auch grössere Fehler an, als den relativen; sie eignen sich demnach nur wenig oder gar nicht zur Erforschung von Details; denn die unvermeidlichen Fehler der absoluten Bestimmungen sind meist grösser, als die zu suchenden sehr kleinen Unterschiede. Ueberdies hafteten den verwendeten Apparaten Mängel an, durch welche die Ungenauigkeit der Resultate meist in ganz unbestimmbarer Weise vergrössert wurde.

Erst 1876 hat Peirce einen der wichtigsten dieser Mängel, nämlich das Mitschwingen des Stativs der Pendel-Apparate erkannt, und dem Einflusse desselben auf die Resultate Rechnung getragen.

Von dieser Zeit an war man bemüht, entweder den Einfluss des Stabilitäts-Mangels des Pendelstatives durch anderweitige Messungen zu ermitteln, und dieserwegen die gefundenen Resultate zu corrigiren, oder, was viel natürlicher ist, durch neue, bessere Constructionen der Apparate diesen schädlichen Einfluss gänzlich zu beseitigen.

Diese Bemühungen können bei uns als der eigentliche Beginn der zweiten Periode angesehen werden, in welcher neuester Zeit die relativen Schwerebestimmungen wieder den ihnen gebührenden ersten Platz einzunehmen beginnen.

Im Grossen und Ganzen sind es dieselben Ziele wie früher, die wir auch jetzt verfolgen, nämlich die Erforschung der wahren Erdgestalt; nur stehen uns gegenwärtig viele Erfahrungen zur Seite, die uns den Weg vorzeichnen, welchen wir zur Erreichung dieses Zieles einzuschlagen haben.

Früher suchte man wesentlich die Abplattung der als Ellipsoïd gedachten Erde zu bestimmen. Es hatten demnach die Messungen den Zweck, die Constanten eines schon vorher als Erdgestalt definirten analytischen Ausdruckes zu bestimmen. Strenge genommen genügten hiezu selbst nur zwei Bestimmungen; in jedem Falle war die Aufgabe durch eine verhältnismässig geringe Anzahl Beobachtungen lösbar.

Heute ist es nicht mehr die Abplattung allein, welche wir durch die Schwerebestimmungen ermitteln wollen, sondern es ist wesentlich der Verlauf des Geoïdes, welchen zu erforschen wir uns zur Aufgabe gestellt haben. Das Geoïd ist jedoch eine sehr unregelmässig verlaufende Fläche, welche sich bekanntlich durch keinen analytischen Ausdruck darstellen lässt.

Wir können demnach ihren Verlauf nur dadurch kennen lernen, dass wir die Coordinaten einer sehr grossen Anzahl von Punkten derselben bestimmen; und es ist daher im Gegensatze zu den früheren Bemühungen jetzt nothwendig, auf einer möglichst grossen Zahl über die ganze Erde gleichmässig und dicht vertheilter Orte die Intensität der Schwerkraft kennen zu lernen.

Wieder sind es die relativen Bestimmungen, welchen der grösste Antheil an der Lösung dieser umfangreichen Aufgabe zufällt, und es treten die absoluten Bestimmungen immer mehr in den Hintergrund; denn die Geodäsie verlangt nur die Vergleichung der Intensität der Schwerkraft für möglichst viele Punkte der Erdoberfläche, keineswegs jedoch eine sehr grosse Genauigkeit in der Bestimmung ihres absoluten Werthes. Wir können den Werth der Beschleunigung (g) der Schwere um 100 Einheiten der 5. Decimale ändern, ohne dass dadurch die Resultate der Vergleichung, auf die es ankommt, merklich afficirt werden.

Ob zwar wir daher den absoluten Werth der Schwere im Allgemeinen schon als bekannt ansehen können, so sollen doch dieserwegen die Bestimmungen desselben noch nicht als abgeschlossen betrachtet werden, umsoweniger, als die bisherigen Angaben für denselben noch beträchtlich von einander abweichen. Dies zeigte sich deutlich durch eine in neuester Zeit ausgeführte Untersuchung. Es wurden nämlich von Wien ausgehend, sehr genaue relative Schwerebestimmungen auf mehreren Orten ausgeführt, auf denen der absolute Werth der Schwere früher schon bestimmt war. Die grosse Verlässlichkeit der Resultate dieser relativen Bestimmungen zeigte sich gelegentlich einer Wiederholung derselben, mit verschiedenen Apparaten, zu verschiedenen Zeiten, und durch verschiedene Beobachter, welche das gleiche Resultat ergab.

Wären die verschiedenen absoluten Bestimmungen vollkommen richtig, so müssten die von ihnen mittels der gemessenen Unterschiede für Wien, geographisches Institut, abgeleiteten Werthe alle gleich sein.

Die Länge des Sekundenpendels Lw. für Wien, geographisches Institut, ergibt sich jedoch aus den Bestimmungen von:

							MM.
1.	Peters	in	Berlin,	1870,	mit Lw.	=	993.745
2.	Lorenzoni	"	Padua,	1885,	"	=	.756
3.	Anton	"	Berlin,	1878,	"	=	.760
4.	Peters	"	Altona,	1869,	"	=	.763
5.	Mahlke	"	Hamburg,	1891,	"	=	.782
6.	Peirce,	"	Berlin,	1876,	"	=	.791
7.	Bessel,	"	Berlin,	1835,	"	=	.804
8.	Biot,	"	Padua,	1820,	"	=	.805
9.	Sabine,	"	Altona,	1828,	"	=	.810
10.	Oppolzer,	"	Wien, (Türkenschanze)	1884,	"	=	.834
11.	Defforges,	"	Paris,	1884,	"	=	.835
12.	Orff,	"	München,	1877,	"	=	.837

Wie wir sehen, zeigen die Resultate nicht unbedeutende Differenzen, welche von systematischen Fehlern herzurühren scheinen. Der Unvollkommenheit der Vergleiche der zu den absoluten Bestimmungen verwendeten Maassstäbe, dürfte ein erhelicher Antheil an denselben zuzuschreiben sein.

Es zeigt sich demnach die Nothwendigkeit, dass dieses fast ausschliesslich in das Gebiet der Physik gehörende Problem, die absoluten Bestimmungen der Intensität der Schwerkraft, nach möglichst verschiedenen Methoden der Lösung zugeführt werde. Hiebei ist es ganz gleichgiltig, an welchen Orten die Bestimmungen vorgenommen werden, da die erhaltenen Resultate stets mittels relativer Bestimmungen untereinander scharf verglichen werden können.

Mit dem Bestreben, den Verlauf der Geoïdfläche aus den Schwerebestimmungen ableiten zu können, ist die Lösung mancher schwierigen Aufgaben eng verbunden.

Sowohl die Discussion der älteren Pendelbeobachtungen, als auch die Ergebnisse neuerer Bestimmungen haben uns nämlich belehrt, dass der Verlauf der Schwerkraft auf der Erdoberfläche kein regelmässiger sei; dass sowohl lokale als auch regionale Störungen derselben vorkommen und es erscheint unerlässlich, das Wesen derselben genau kennen zu lernen.

Wir kennen heute noch sehr wenig den Einfluss, welchen die Continente und Meere, die Gebirge, Hoch- und Tiefebenen, sowie die verschiedenen geologischen Formationen auf die Schwere ausüben.

Die Reductionen, mittels welchen die Beobachtungen nothwendigerweise vergleichbar gemacht werden müssen, sind uns gleichfalls nicht vollkommen bekannt, wenigstens weichen diesbezüglich die Meinungen noch sehr voneinander ab; endlich gibt es noch eine ganze Reihe von höchst interressanten, doch noch unerforschten Problemen, welche mehr in das Gebiet der Geophysik gehören, die jedoch gleichfalls nur durch Schwerebestimmungen gelöst werden können; so z. B. das Verhalten der Schwere beim Eindringen in die Erde, also in den Schachten der Bergwerke, Tunnels, etc. Erst an drei Örtlichkeiten sind über diese interressante Aufgabe Versuche unternommen worden, nämlich in den Bergwerken zu Harton in England, Pribram in Böhmen, und Freiberg in Sachsen.

Wie wir sehen, ist die durch Schwerebestimmungen zu lösende Aufgabe eine sehr grosse; denn abgesehen von den sehr zahlreichen über die ganze Erde vertheilten Beobachtungen, welche uns das Materiale zur Bestimmung des Verlaufes der Geoïdfläche zu liefern bestimmt sind, benöthigen wir auch eine grosse, nach Tausenden zählende Zahl meist dicht beieinander gelegener Beobachtungs-Stationen, zur gründlichen Erforschung der mit dieser Aufgabe im Zusammenhange stehenden Probleme.

Mit den bis vor kurzer Zeit im Gebrauche gestandenen Apparaten dieses Ziel zu erreichen, war aussichtslos, denn die Beobachtungen waren sehr mühsam und zeitraubend, daher auch sehr kostspielig.

Mit Hilfe des neuen Sterneck'schen Pendelapparates, der in vielen Staaten bereits in Verwendung ist, ist es möglich, mit Aussicht auf Erfolg, die Erreichung dieses Zieles anzustreben, indem die Beobachtungen bei sehr grosser Genauigkeit wesentlich vereinfacht sind, und überall, auch auf schwer zugänglichen Orten leicht ausgeführt werden können.

Mit demselben war es in jüngster Zeit ermöglicht, dass in Österreich Ungarn seitens des k. u. k. militär-geographischen Institutes die ersten detaillirten Untersuchungen über das Verhalten der Schwere in verschiedenen Terrain- und geologischen Formen ausgeführt werden konnten.

Es wurden die Alpen, die Karpaten, die ungarische Tiefebene, das Bihíar-Gebirge und noch andere interressante Örtlichkeiten mit einer Reihe von mehreren hundert enganeinander liegenden Schwerestationen durchguert und hiedurch viele wichtige und interressante Aufschlüsse über das Verhalten der Schwere erzielt.

Massendefecte und Massenanhäufungen under der Erdoberfläche wurden constatirt, systematische Unterschiede der Schwere über primäre Formen und Sedimenten aufgefunden, etc.

Jedes einzelne verhältnismässig leicht und schnell auf diesem noch unerforschten Gebiete zu erwerbende Resultat ist interressant, lehrreich und wichtig, u. z. nicht nur für die Geodäsie, sondern auch für Geophysik und Geologie; ja es kann heutzutage das Pendel auch als ein unerlässliches geologisches Instrument angesehen werden.

Derartige Apparate wurden bereits in grosser Anzahl von Wien aus nach vielen Staaten geliefert; bei jedem einzelnen wurden die Constanten und die Schwingungszeiten der Pendel genau ermittelt, und zwar an jenem Orte in Wien, wo Oppolzer den absoluten Werth der Schwere sehr genau bestimmt hat. Hiedurch ist eine grosse Vereinheitlichung bezüglich der Angaben für die Schwere angebahnt.

Gewiss wird sich binnen kurzer Zeit unser Wissen über diese und ähnliche Verhältnisse klären, umsomehr, wenn einmal, was in nächster Zeit zu erwarten ist, in mehreren Staaten an verschiedenen Orten ähnliche Detailstudien ausgeführt sein werden. Durch dieselben werden wir erst im Stande sein das zahlreiche über die ganze Erde vertheilte Beobachtungs-Materiale richtig zu verwerthen.

Dieses zu beschaffen, ist gegenwärtig die wesentlichste Aufgabe. Denn das von unseren Vorfahren ererbte Materiale, aus dem Anfange dieses Jahrhunderts ist viel zu spärlich und nicht immer strenge vergleichbar.

Es muss ein neues, gleichmässig über die ganze Erde vertheiltes, gleichwerthiges, Tausende von Stationen umfassendes Materiale zum Zwecke der Erforschung der wahren Erdgestalt geschaffen werden.

Wenn auch zu hoffen is, dass bei dem regen Interresse, welches sich gegenwärtig, nach so langer Zeit, allerorten für die Schweremessungen wieder kundgibt, auf dem Festlande bei allen Culturstaaten in nicht allzu langer Zeit sehr zahlreiche Messungen ausgeführt sein werden, so repräsentirt die hiedurch untersuchte Fläche doch nur einen geringen Theil der gesammten Erdoberfläche. Der weitaus grösste Theil derselben ist uns nur durch weite Reisen zugänglich, die Ausführung der Beobachtungen daher für den Einzelnen viel zu zeitraubend und kostspielig.

In richtiger Erkenntniss dieser Verhältnisse und stets bestrebt

die Reisen Sr. Majestät Kriegsschiffe auch der Wissenschaft möglichst nutzbar zu machen, hat sich die k. u. k. Österreichisch-ungarische Kriegs-Marine-Verwaltung aus eigener Initiative bewogen gefunden, die Schwerebestimmungen in das Reise-Programm der Kriegsschiffe aufzunehmen.

Es wurden zu diesem Zwecke zwei Sterneck'sche Pendelapparate angeschafft und Seeoffiziere im k. u. k. militär-geographischen Institute mit der Ausführung der Schwerebestimmungen gründlich vertraut gemacht. Gegenwärtig befinden sich bereits zwei Schiffe mit completten Apparaten ausgerüstet in den ostasiatischen Gewässern, und ist die Ausrüstung eines dritten Schiffes für das mittelländische Meer bereits im Zuge.

Auf zahlreichen Stationen werden Beobachtungen ausgeführt werden, und lässt das grosse Interresse der Seeoffiziere an der Sache, die gute Schulung derselben, sowie die Einfachheit des Apparates und der Beobachtungen den besten Erfolg erhoffen.

Hiemit hat die k. u. k. Kriegs-Marine den richtigen Weg gezeigt, auf welchem es möglish ist, in relativ kurzer Zeit das für die Wissenschaft nothwendige, reichhaltige Materiale zu beschaffen.

Möge ihre Initiative auf die anderen seefahrenden Nationen anregend wirken, und eine baldige allgemeine Betheiligung an diesem Unternehmen zur Folge haben. Dann können wir hoffen, trotz der vielen Schwierigkeiten doch das angestrebte schöne Ziel zu erreichen, denn was der Einzelne nicht vermag, gelingt leicht mit vereinten Kräften.

R. v. STERNECK, *Oberstlieutenant.*

WIEN, im Januar 1893.

Chevalier D'Happoncourt then read the following translation prepared by himself:

The attempts which have been made to ascertain the figure of the earth from determinations of gravity are of comparatively recent date, and belong almost exclusively to the present century. The measurement of the lengths of degrees of the meridian has gradually developed itself during 2000 years, from the first discovery of the rotundity of the earth up to the present position of the science of geodesy, but gravity observations, from the time of their com-

mencement, have supplied fairly reliable data for the determination of the earth's figure, for they were already assisted by the highly developed theories of geodesy.

Thus it comes about that even now, at the close of the same century, we can still use, for the study of gravity on the earth, the material obtained at the beginning of this century; indeed, it is almost all that we can use, for new material only exists to a small extent, and this does not always exceed the old data in quality and trustworthiness.

In the attempts to make gravity determinations useful to geodesy, two periods are to be distinguished; one at the beginning, and one at the end of our century. These are separated from each other by a long interval, during which nothing, or very little of any use, was accomplished.

In the first period are included those numerous and excellent determinations of gravity to which we owe, for the most part, our present knowledge of the figure of the earth as indicated by gravity determinations, and which also afford us information as to the distribution of gravity over the earth generally.

The names of those men who have furnished these important and valuable materials to science are well known to every one.

This fertile period comes, we may say, to a sudden termination with the fundamental investigations of Bessel.

The second period of these inquiries, which brings us down to the present time, was developed, first, by the measurement of degrees of the meridian in Europe, which has now become the international measurement of the earth, and has included gravity determinations in its programme.

During the second period of these inquiries, the determinations of gravity in Europe have yielded but few good results, inferior to those of the first period as regards accuracy, because it was supposed that the relative determinations which were previously employed, and which are so trustworthy, might be replaced by absolute measurements. But however accurately *absolute* measurements are carried out, they are always affected by numerous, and for the most part also by greater, errors than the relative ones; they are therefore but little, if at all, suited for the investigation of details; for the unavoidable errors of the absolute determinations are mostly larger than the very small differences which they are intended to ascertain. Moreover, there exist in the apparatus employed defects by which

the inaccuracy of the results is increased in a way which it is generally quite impossible to determine.

In 1876, Peirce first perceived one of the most important of these defects, viz., the oscillation of the framework of the pendulum apparatus, and took that in account upon the results he obtained.

From this time it has been endeavored either to deduce the influence of the want of stability of the pendulum framework by further measurements, and by these means to correct the results obtained, or, what is more natural, to remove altogether this injurious effect by a better construction of the apparatus.

We may regard these efforts as the beginning of the really valuable work of the second period, in which *relative* determinations of gravity resumed the first place, which properly belongs to them.

On the whole, we still pursue the same object as before, viz., the investigation of the true figure of the earth, but we have now the advantage of much experience which indicates to us the line that we should follow for the attainment of the object in view.

Formerly, we really endeavored to determine the difference between the longest and shortest diameters of the earth, which was considered to be an ellipsoid. Accordingly the object of the measurements was to determine the constants of an analytical expression, previously defined as the figure of the earth. Theoretically speaking, two determinations were quite sufficient for this purpose; and in any case the problem could be solved by a relatively limited number of observations.

At the present day it is not only the oblateness that we wish to deduce by determinations of gravity, but it is really the shape of the geoid which we have set ourselves the task of investigating. The geoid is, however, a surface which is very irregular in shape, and which we know will not admit of representation by any analytical expression.

Thus we can only ascertain its course by the determination of the coördinates of a very large number of points; and it is therefore now necessary, contrary to former efforts, to ascertain the intensity of the force of gravity at as great a number of places as possible, uniformly and closely arranged over the whole earth.

It is, again, the relative determinations to which the greatest share in the solution of this comprehensive problem falls, and the *absolute* determinations continually recede into the background; for geodesy requires only the comparison of the intensity of the force

of gravity at as many points of the earth's surface as possible, but in no wise very great accuracy in the determination of their absolute value. We may change the value of the acceleration (g) of gravity by 100 units of the fifth decimal, without thereby perceptibly affecting the results of the comparison on which it depends.

Although, therefore, we may regard the absolute value of gravity in general as already known, yet we must not on this account consider its determination as definitely set at rest, especially as the results hitherto obtained still differ considerably from each other. This is clearly shown by the following investigation, carried out quite recently. Starting from Vienna, very accurate relative determinations of gravity were carried out at many stations at which the absolute value had been already previously determined.

The thorough trustworthiness of the results of these relative determinations was proved on the occasion of their repetition with different apparatus, at different times, and by different observers, which led to the same result.

If the various absolute determinations had been perfectly correct, the results deduced from them by means of the differences determined for Vienna Geographical Institute must all be the same.

The results are as follows, expressed in the lengths of the seconds pendulum L.W., for Vienna Geographical Institute, as deduced from absolute determinations by

						MM.
1. Peters	in	Berlin,	1870,	L.W.	=	993.745
2. Lorenzoni	"	Padua,	1885,	"	=	.756
3. Anton	"	Berlin,	1878,	"	=	.760
4. Peters	"	Altona,	1869,	"	=	.763
5. Mahlke	"	Hamburg,	1891,	"	=	.782
6. Peirce	"	Berlin,	1876,	"	=	.791
7. Bessel	"	Berlin,	1835,	"	=	.804
8. Biot	"	Padua,	1820,	"	=	.805
9. Sabine	"	Altona,	1828,	"	=	.810
10. Oppolzer	"	Vienna, (Türkenschanze)	1884,	"	=	.834
11. Defforges	"	Paris,	1884,	"	=	.835
12. Orff	"	Munich,	1877,	"	=	.837

As we see, the results exhibit some important differences, which appear to be attributable to systematic errors. We may put down some of them to imperfection of the comparisons of the scales used for the absolute determinations.

This shows the necessity of referring this problem, viz., the *absolute* determination of the intensity of the force of gravity, which belongs almost exclusively to the domain of physics, to as many different methods of solution as possible. For this purpose it does not matter at which places the determinations are made, as the results obtained can always be closely compared with each other by means of relative determinations.

The solution of many difficult problems is closely connected with the endeavor to ascertain the form of the geoïd surface by means of gravity determinations.

The discussion of the older pendulum observations, as well as the results of more recent determinations, have taught us that the distribution of the force of gravity on the surface of the earth is not regular, but that local and regional disturbances occur, and it appears indispensable to ascertain their nature accurately.

Even at the present time we know little about the influence which the continents and seas, the mountains, plateaus and low plains, as well as the various geological formations, exert upon gravity.

The reductions which must necessarily be applied to the observations, in order to make them comparable with each other, are not thoroughly understood; at least, opinions about them still differ considerably. Lastly, there is still a whole series of highly interesting but yet unexamined problems, which belong more to the domain of terrestrial physics, but which can also only be solved by determinations of gravity; so, for instance, the behavior of gravity beneath the surface of the earth, such as in the shafts of mines, in tunnels, etc. Experiments have been undertaken in this interesting problem in only three localities in Europe, viz., in the mines at Harton in England, Pribram in Bohemia, and Freiberg in Saxony.

As we see, the problem to be solved by determinations of gravity is a very serious one; for, apart from the very numerous observations distributed over the whole earth which are available for furnishing materials for the determination of the form of the surface of the geoid, we require for the thorough investigation of the problems in connection with this subject, a large number of observing stations, amounting to thousands, and in close proximity to each other. It was impracticable to attain this end with the apparatus in use up to a short time ago, for the observations were very troublesome, and required much time, and were consequently costly.

By the help of Sterneck's new pendulum apparatus, which is already in use in many countries, it is possible to aspire to the attainment of this object with a prospect of success, as observations are materially simplified and yet possess very great accuracy and can be easily made everywhere, even at places which are difficult of access.

With this apparatus it was practicable, quite recently, for the Vienna Military-Geographical Institute to carry out in Austro-Hungary the first detailed investigations on the distribution of gravity in various soils and geological formations.

A series of several hundred closely connected gravity stations was established in the Alps, the Carpathians, the Hungarian lowlands, the Bihar mountains, and other interesting localities, and by this means many important and interesting results relating to the distribution of gravity were obtained.

The existence both of deficiency and of excess of mass beneath the surface of the earth was proved; systematic differences of gravity over primary formations and sedimentary deposits were discovered, etc.

Every individual result which is relatively easily and quickly obtainable in this yet unexplored domain is interesting, instructive and important, not only as regards geodesy, but also for terrestrial physics and geology; in fact, the pendulum may, at the present day, be regarded as an indispensable geological instrument.

Instruments of this pattern are already supplied in great numbers from Vienna to several countries; the constants of each, and the vibration times of the pendulums, are accurately determined at the place, in Vienna, where Oppolzer has very accurately determined the absolute value of gravity. By this means, a great uniformity of results is effected.

Within a short time, our knowledge of these and similar conditions will certainly be more definite if similar detailed experiments are carried out at different places in several countries, which may shortly be expected. By these means we shall, for the first time, be in a position to utilize properly the numerous data distributed over the whole earth.

This is the most essential task at the present day; for the materials inherited from our predecessors since the commencement of the present century are far too scanty and are not always strictly comparable with each other.

For the purpose of determining the true figure of the earth, we must obtain a mass of new material of uniform character, uniformly distributed over the whole earth, and representing thousands of stations.

If, as it is to be hoped—owing to the keen interest which, after so great a lapse of time, is again exhibited on all sides with regard to determinations of gravity—very numerous measurements are undertaken at no very distant period by all civilized countries on the continent of Europe, the area thus investigated only represents a small portion of the whole surface of the globe. By far the greatest part of the globe is only accessible by distant voyages, and the execution of the observations by means of private persons would take too much time and money.

The Austro-Hungarian Admiralty has always had a true perception of the circumstances above mentioned, and has taken the initiative by including observations of gravity among the duties to be performed by ships at foreign stations, in order to make the voyages of the ships belonging to their navy as useful to science as possible. For this purpose two of Sterneck's pendulum instruments have been procured, and the officers of the navy have been made thoroughly familiar, at the Vienna Military Geographical Institute, with the carrying out of gravity determinations. At the present time, there are already two ships in the China seas which are furnished with complete apparatus, and the equipment of a third vessel for the Mediterranean is already in progress.

Observations will be taken at numerous stations, and we may fairly hope for very good results, from the great interest the officers have taken in the subject and their good education, as well as from the simplicity of the apparatus and of the observations themselves.

The Ministry of Marine has thus shown the right way by which it is possible to secure for science, in a relatively short space of time, a copious amount of necessary data.

I may, in conclusion, express the hope that their initiative may stir up other maritime powers and result in a speedy, general participation in this undertaking. We may then hope that, in spite of the many difficulties, the important object in view may soon be attained; for what individuals cannot do may be easily accomplished by united forces.

(Signed) R. v. STERNECK, *Oberst Lieutenant.*

VIENNA, January, 1893.

President Fraley next introduced Dr. Isaac Roberts, who addressed the Society as follows:

I am delegated by the Royal Astronomical Society of England to convey to you their hearty good wishes on this anniversary of your Society, and hope that your career in the future will be even more prosperous than in the past.

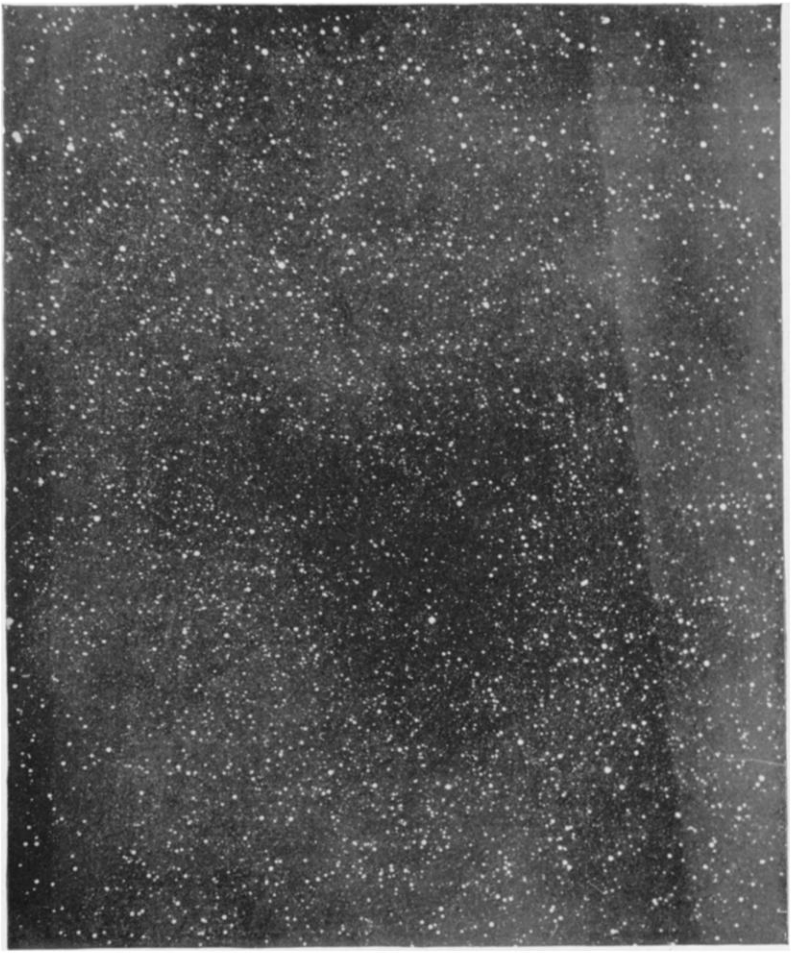
I have brought with me a few specimens of the work that has been done in England, so that those present at the meeting may have an opportunity of judging somewhat of the way in which we work there. The subject involves a series of photographs, and the most convenient place for exhibiting them happens to be at the back of this room; it is therefore probable that the audience will desire to turn their backs on you, Mr. President, for a while, so that they may see on the photographs the references which I may have to make, and, with your permission, I shall have to be within reach of the photographs so that I may point them out.

My remarks may be entitled, "Illustrations of Progress Made During Recent Years in Astronomical Science." I am rather at a disadvantage in not knowing to what extent the field of astronomical science has been exhibited to you at the meetings which have preceded this one, and I therefore feel the risk that I incur of repeating much of what may have been already laid before you in form and substance better than I can submit it. I shall, therefore, assume that reference to the progress made in astronomical science between the time of the foundation of this Society and about the year 1850 may by me be omitted.

The selection of the year 1850 as the time for the commencement of my narrative will be appreciated, because it was in that year that your illustrious countryman, George P. Bond, produced with the fifteen-inch Harvard refractor, a very successful photograph of the moon, which was exhibited at the great Exhibition in London, in 1851. Another of your illustrious countrymen, Dr. J. W. Draper, of New York, had, as early as the year 1840, taken photographs of the moon, and in the subsequent year he succeeded in the application of the photographic method to the delineation of the solar spectrum. Bond also, in 1850, photographed, with the fifteen-inch Harvard refractor, the bright stars Castor and Vega, and, in 1857, initiated the photography of double stars.

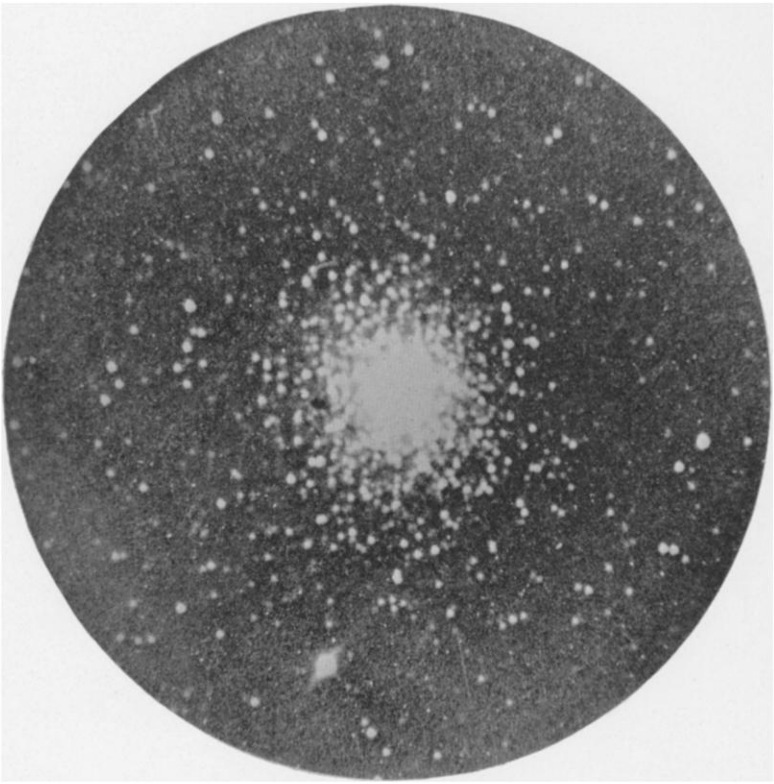
Of course, in England and in France, celestial photography was successfully carried on concurrently with similar work in America, and it would be difficult to assign a sharp line of demarcation which would place any one of these countries far in advance of the others in the keen but noble efforts to enlarge the boundaries of knowledge by the application of the newly-discovered powers of photography. Warren De la Rue, in England, in 1853, produced excellent photographs of the moon, and, in 1858, instituted the method of photographing sun spots, which was effected continuously until 1872. In France, Foucault and Fizeau also photographed the sun, in 1845; and in America, Rutherford, in 1864, made an important step in advance by the construction of a telescope with an objective of eleven and a half inches aperture, corrected, not for visual observation, but exclusively for photographic work. This was improved, in the year 1885, by the brothers Henry, of Paris, who constructed a photo-telescope of thirteen inches aperture, and with it succeeded in photographing stars of the sixteenth magnitude, in May, of that year; and it so happened that I also had a reflecting telescope made, having an aperture of twenty inches, with which I commenced, in May, 1885, to chart the stars in the Northern hemisphere of the sky on a scale about double that adopted by Argelander. But Dr. Gill, the Director of the Cape Observatory, and the late Admiral Mouchez, Director of the Paris Observatory, proposed and admirably carried into execution a scheme of charting the stars by photographic instruments of identical aperture, focal length and chromatic corrections as those adopted in the Paris instrument made by the Henrys. There are now eighteen of those telescopes in observatories, situated in different parts of the world, regularly engaged in taking photographs of the sky, so as to produce a great chart of all the stars down to the fourteenth magnitude. Therefore, the charting which I had commenced is superseded by a more efficient method, and my twenty-inch reflector, practically, is turned to use in photographing nebulæ and clusters of stars, an employment for which it is better adapted than the thirteen-inch photo-refractors used in the charting.

The merits of the reflector in photographing faint stars and faint nebulosity was pointed out by Dr. Common, in England, in the year 1883, and my experience since fully confirms his. I must not here attempt even a cursory description of the great work done during recent years in the photographing of solar, stellar and nebular



Stars in Cygnus.

Plate I (Roberts).



M. No. 13, Herculis.

Plate II (*Roberts*).

spectra. The field is too extensive and the ardent workers too numerous for inclusion in this brief statement. I shall, therefore, as the representative of the Royal Astronomical Society of England, introduce to your notice a selection of thirteen photographs, which are copies of some which have been presented to the Society and described at the meetings of the Fellows at various times during the past seven years, and I may be permitted to add, that they represent the fullest information we yet possess concerning the objects they portray.

The first (Pl. i.) is a photograph of the stars in the Milky Way in Cygnus. When you examine it closely, you will find it is almost covered with stars, not one of them visible to the sight without the aid of the telescope, many of them invisible even with powerful telescopes. This is an area of the sky that would be covered by one of your smallest silver coins, held between the finger and thumb, at arm's length, between the eye and the sky; the area of sky covered by such a piece would be about equal to what this photograph represents. The centre of the photograph is in R. A. 19 h. 45 m., decl. N. 35 deg. 30 m., and covers a sky area of about 2 deg. 3 m. by 1 deg. 45 m. It has been enlarged from the negative to a scale of 26 seconds of arc to 1 millimeter, and was taken with the twenty-inch reflector, on August 14, 1887, with an exposure of sixty minutes. A photograph comparable with this, was taken by the brothers Henry, in Paris, in August, 1885, with the thirteen-inch photo-refractor, and was one of the early marvels of celestial photography. It showed about 3000 stars on the sky area just described, but the photograph taken with my twenty-inch reflector, and now exhibited, shows no less than 16,000 stars on the same coincident area of the sky. Allowing for difference in aperture between the two telescopes, there is still a wide margin in favor of the reflector for this kind of work.

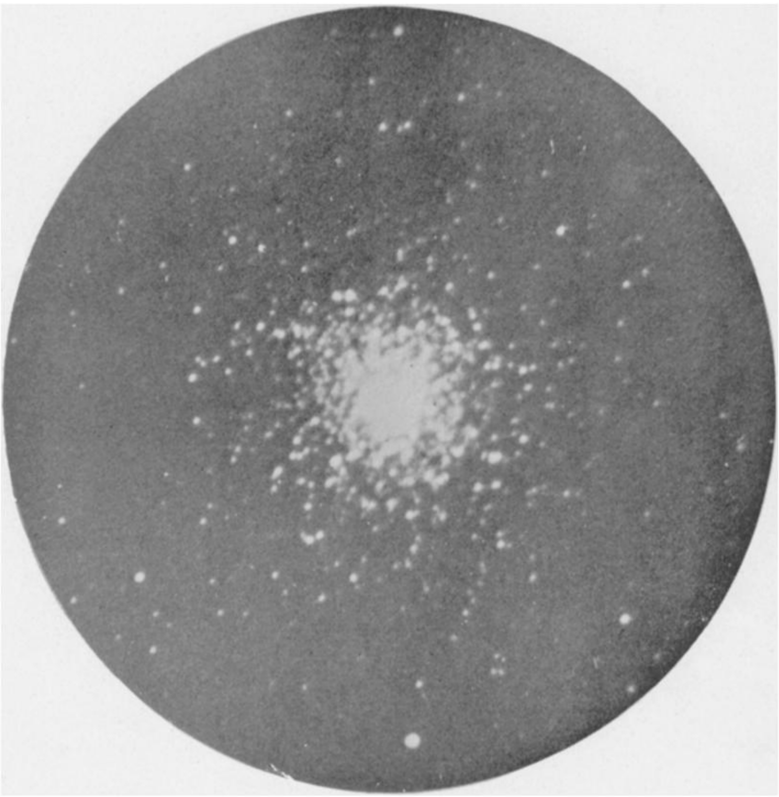
The next photograph (Pl. ii.) is known as M. 15, in the constellation Pegasus, in R. A. 21 h. 25 m., decl. N. 11 deg. 41 m. The scale is 6 seconds of arc to 1 millimeter, and the field is 18 minutes of arc in diameter. The photograph was taken with the twenty-inch reflector, on November 4, 1890, with an exposure of two hours, and shows a fine example of a globular cluster, but the written descriptions of it, from eye observations, do it scant justice, and there are no drawings available for comparison. The photograph shows the central part of the cluster to be involved in nebulosity, as is also

the case with other globular clusters. Surrounding the cluster are curves and festoons of stars, which is a characteristic of these objects. Eye observations do not reveal the existence of the involved nebulosity which, on the plate, is sufficiently dense to obscure the stars, though they are visible through the nebulosity on the negative.

The next photograph (Pl. iii.) is of the cluster known as M. 13, in the constellation Hercules, and is in R. A. 16 h. 38 m., decl. N. 36 deg. 39 m. The scale is 6 seconds of arc to 1 millimeter, and the field or circle is 18 minutes of arc in diameter. The photograph was taken with the twenty-inch reflector and an exposure of one hour, on May 22, 1887, and delineates one of the finest globular clusters in the heavens, containing thousands of stars densely packed together at the centre and with curvilinear streams of stars radiating from it. Lord Rosse detected three dark lanes or rifts in its interior, forming something like the letter Y, which is distinctly shown on the photograph and more strikingly visible on the negative. No drawing can possibly do justice to an object like this, which is portrayed by photography in one hour. Moreover, it shows the cluster involved in nebulosity obscuring the stars at the centre, a fact which observers had hitherto failed to perceive.

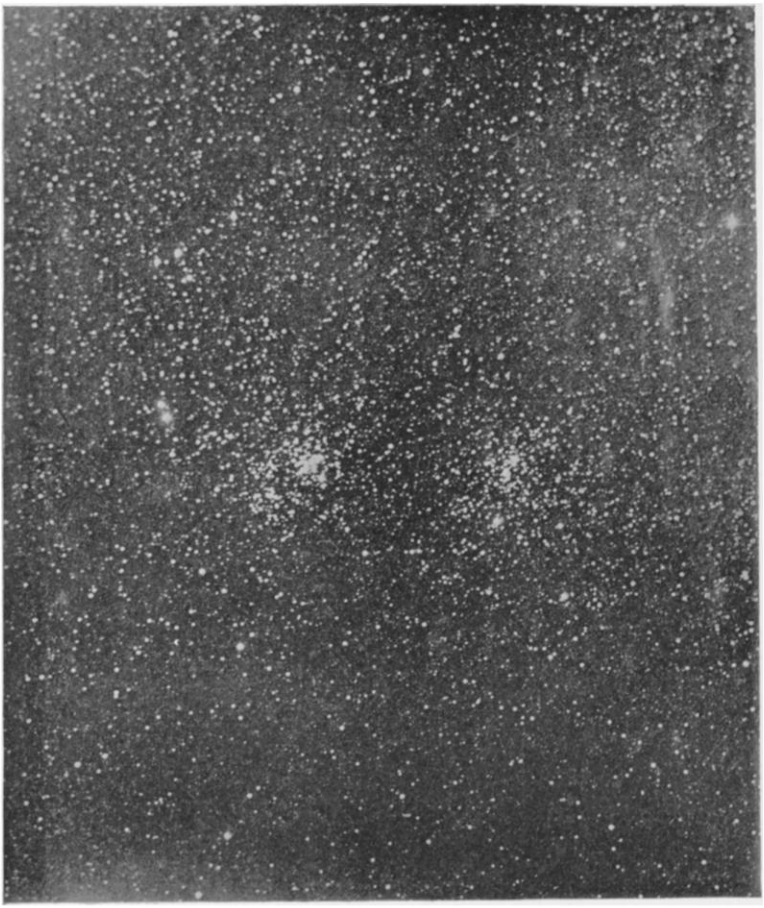
The next photograph (Pl. iv.) is known as Herschel VI., No. 33 and No. 34, in Perseus, having R. A. 2 h. 11 m., decl. N. 56 deg. 38 m. The scale is 24 seconds of arc to 1 millimeter, and the photograph covers the sky area of 1 deg. 54 m. by 1 deg. 38 m. It was taken with the twenty-inch reflector, on January 13, 1890, with an exposure of three hours. These gorgeous clusters, in the sword-hand of Perseus, reveal one of the most brilliant objects in the heavens. To chart their component stars by eye observations and measurements would be an exceedingly protracted task, and even then it would only be imperfectly done. The photograph gives a perfectly accurate picture of these thousands of stars in a very short time, the relative position and magnitude of each one being correctly delineated, so as to form a reliable basis for future investigation concerning their variability and relative movements.

Next (Pl. v.) is a photograph of the ring nebula, M. 57 Lyræ. It is in R. A. 18 h. 49 m., decl. N. 32 deg. 52 m. The scale is 4 seconds of arc to 1 millimeter, and the diameter of the field is 12 minutes of arc. The photograph was taken July 27, 1891, with the twenty-inch reflector and an exposure of thirty minutes. The nebula is the best known and brightest of the class of annular



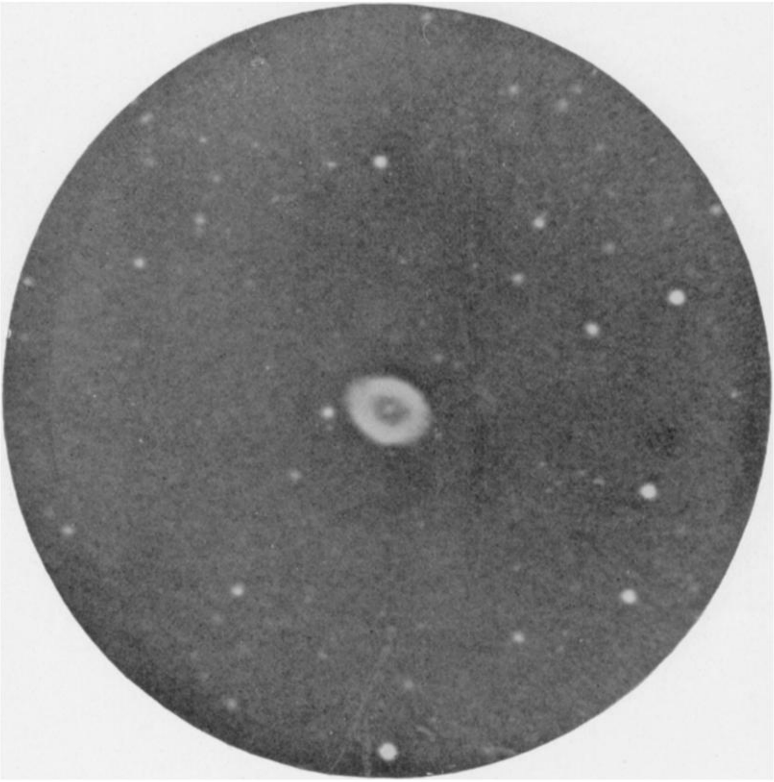
Cluster M. 15, Pegasi.

Plate III (*Roberts*).



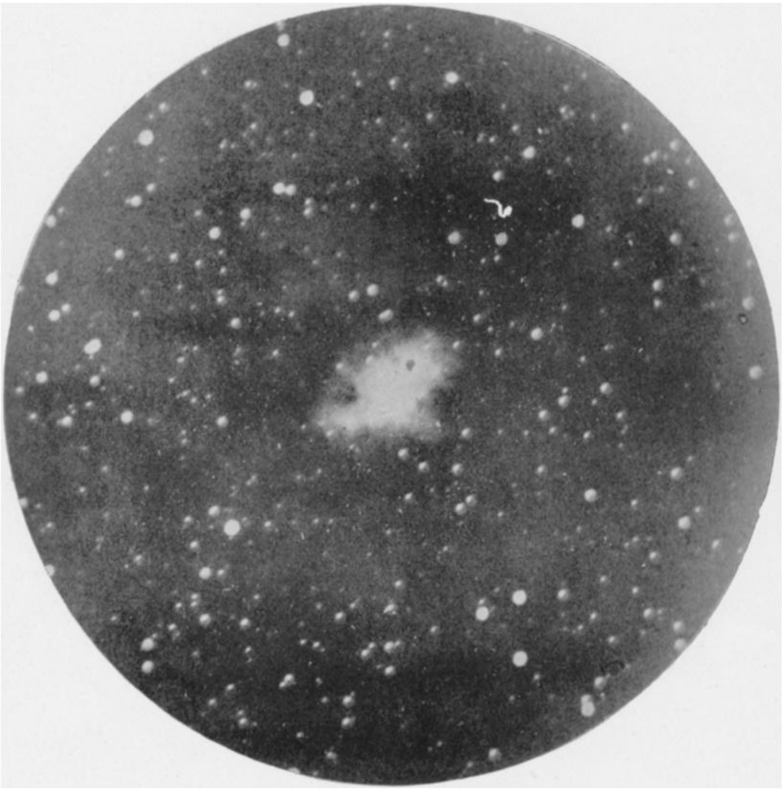
Herschel VI, Nos. 33 and 34.

Plate IV (Roberts).



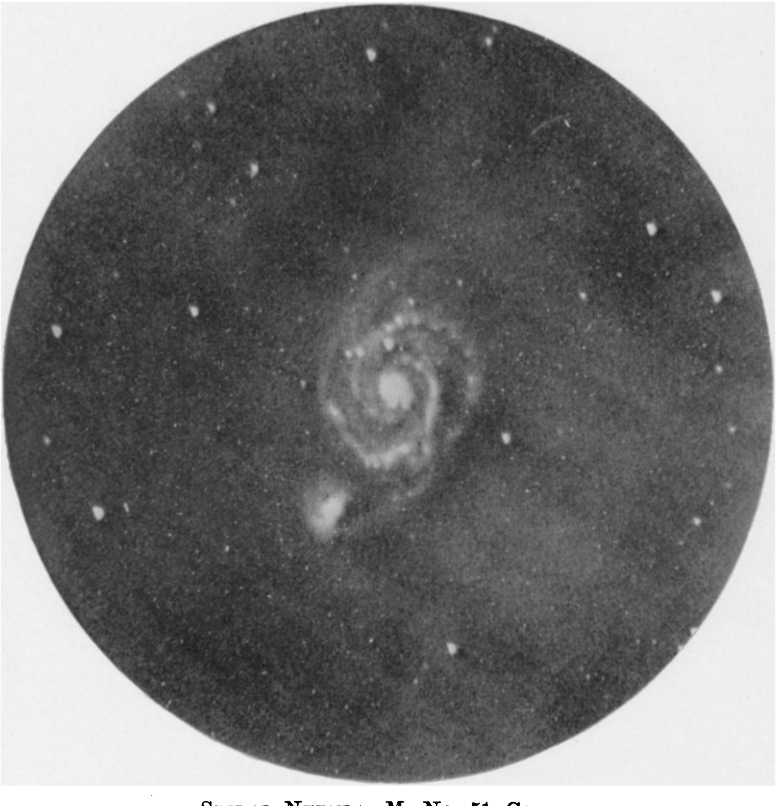
RING NEBULA, M. 57, LYRÆ.

Plate V (*Roberts*).



Crab Nebulæ, M. 1, Tauri.

Plate VI (Roberts).



SPIRAL NEBULA, M. No. 51, CANUM.

Plate VII (*Roberts*).

NEBULÆ IN URSA MAJOR.

Plate VIII (*Roberts*).

nebulæ, and the photograph confirms in general outline the observations of Herschel and Lord Rosse, but there is no indication of the filamentous projections shown on one of the drawings. On the other hand, the central star inside the ring is conspicuous on the photograph though not shown on the drawings.

The next photograph (Pl. vi.) is that of the crab nebula, M. 1, in the constellation Taurus. This nebula is in R. A. 5 h. 28 m., decl. N. 21 deg. 57 m. The scale is 8 seconds of arc to 1 millimeter, and the field is 24 minutes of arc in diameter. The photograph was taken with the twenty-inch reflector, on February 2, 1892, and an exposure of three hours. In Lord Rosse's drawing, which is familiar as a popular illustration, the nebula somewhat resembles a pineapple, with hair-like appendages; but the photograph shows it to be irregular, oval in outline, with a deep indentation on the following side, and immediately opposite to this is a protuberance of faint nebulosity. The nebula, generally, is very bright and granular in structure, with patches of unequal density involved, and the outer margin is faint and ill-defined.

Next is the photograph (Pl. vii.) of the spiral nebula, M. 51 Canum. This nebula is in R. A. 13 h. 25 m., decl. N. 47 deg. 45 m. The scale is 8 seconds of arc to 1 millimeter, and the field is 24 minutes of arc in diameter. It was taken with the twenty-inch reflector, April 28, 1889, with an exposure of four hours. This nebula is the most striking of the spiral form, and the published drawings of it by Lassell and Lord Rosse are, perhaps, the best known and in outline are in fair agreement with the photographs. Both the drawings, however, fail to give an adequate idea of the real structure of this remarkable object, which is here correctly depicted for the first time. The stars and condensed patches of nebulosity follow closely all the whorls of the nebula, and are strikingly seen on the photograph, though only imperfectly shown on the drawings.

Next is the photograph (Pl. viii.) of the nebulæ, M. 81, 82, and a nebulous star in Ursa Major, with centre in R. A. 9 h. 46 m., decl. N. 69 deg. 39 m. The area of the sky included is about 1 deg. 16 m. by 1 deg. 4 m. The scale is 16 seconds of arc to 1 millimeter. The photograph was taken with the twenty-inch reflector, March 31, 1889, with an exposure of three hours and thirty minutes. The nebula south is M. 81, which is on this photograph shown for the first time to be a spiral with a dense nucleus.

The nebula on the north is M. 82, and appears as a bright ray, due to its being viewed edgewise from our position on the earth. A nebulous star is also visible on the south, near the edge of the plate.

Next is the photograph (Pl. ix.) of the dumb-bell nebula in Vulpecula. It is in R. A. 19 h. 55 m., decl. N. 22 deg. 25 m. It covers a sky area of 1 deg. 26 m. by 1 deg. 13 m. The scale is 18 seconds of arc to 1 millimeter. It was taken with the twenty-inch reflector, on October 3, 1888, with an exposure of three hours. The drawings of the nebula by Herschel and Lord Rosse are familiar as illustrations in text-books, but when they are compared with the photograph they fail to show the outlines and details which it reveals. The brighter part is not shown in the shape of a dumb-bell, strictly, but as a vast, globular mass, surrounded by a wide, nebulous ring, which is seen as a projection at both sides and encroaching on the globular mass, which is also broken up into flocculent patches.

Next is the photograph (Pl. x.) of the nebulæ in the Pleiades. The sky area shown is 1 deg. 26 m. by 1 deg. 13 m., on a scale of 18 seconds of arc to 1 millimeter. The photograph was taken with the twenty-inch reflector, December 8, 1888, with an exposure of four hours. The stars visible to the eye in the Pleiades are five in number, and in 1859 Tempel discovered that the star *Merope* was involved in faint nebulosity. Some further traces of nebulous light in the group were suspected in a vague, indefinite way, by Weiss and other observers using large telescopes. In 1885, the Henrys obtained a photograph which showed a trace of nebulosity near three of the bright stars ; namely, three streamers across *Merope*, and a little projection from *Maia*, also a horn-like projection from *Electra*. My first photograph—taken in December, 1886, with three hours' exposure—proved the existence of extensive nebulous patches and streamers scattered over the whole group and probably forming parts of one vast nebula. The present photograph exhibits these features as far as they are at present known.

Next are two photographs (Pls. xi. and xii.) of the great nebula in Orion. The sky area covered is 1 deg. 16 m. by 1 deg. 4 m., on a scale of 16 seconds of arc to 1 millimeter. Pl. xi. was taken with the twenty-inch reflector, December 24, 1888, with an exposure of eighty-one minutes. The other (Pl. xii.), with an exposure of three hours and twenty-five minutes, was taken on February 4, 1889,

DUMBBELL NEBULA M. 27, VULPECULÆ.

Plate IX (Roberts).

NEBULÆ IN THE PLEIADES.

Plate X (*Roberts*).

Great Nebulæ in Orion.

Plate XI (*Roberts*).

GREAT NEBULÆ IN ORION.

Plate XII (Roberts).

Great Nebula in Andromeda.

Plate XIII (Roberts).

shows the structure and details of the central nebulosity with greater clearness than the first. The second shows vastly more extensive nebulosity than the first, but the central part is too dense on the negative to print on the paper enlargement. The stars and all details of the central nebulosity are, nevertheless, clearly visible on the negative. These two photographs, when correlated with each other, show the great nebula more completely and truly than it was previously known; and, though many drawings have been made and ably discussed by Prof. Holden in his elaborate monograph on the Orion nebula, they only show how utterly untrustworthy eye observations are. The first photograph of this object was obtained by Dr. Draper, in 1880, with an eleven-inch refractor, his best one being obtained in March, 1882, with an exposure of 137 minutes. The next advance was by Dr. Common, in 1883, with his three-foot reflector and an exposure of 37 minutes. This, in turn, has been much distanced by the present photograph, which shows an enormous extension of nebulosity and much delicate detail not before seen.

On the photograph of the great nebula in Andromeda (Pl. xiii.), the sky area covered is 1 deg. 54 m. by 1 deg. 38 m., on a scale of 24 seconds of arc to 1 millimeter, and was taken with the twenty-inch reflector, December 29, 1888, with an exposure of four hours. The nebula is one of the largest in the heavens, and has been known ever since the invention of the telescope as a long, oval nebulosity, ill-defined at the margin. Bond, in 1847, and Trouvelot, later, with the fifteen-inch Harvard refractor, detected two large, longitudinal rifts on one side of it. No advance was made beyond this until my photograph, taken on October 10, 1887, revealed its true form for the first time. The nebula is shown to be symmetrically oval and encompassed by elliptical rings, separated by dark divisions extending completely around it. There are a great many stars involved, apparently, in the nebula, which the photograph shows in their true relative positions, together with the structure and details of the nebulosity.

In conclusion, I shall only be uttering a truism when I say that we are yet only at the threshold of knowledge of the stellar universe, though the progress made during the past ten years encourages us to hope that ere the Two Hundredth Anniversary of the Philosophical Society of Philadelphia shall be held much will be known concerning the movements of the solar system in space, the general drift

of the stars, the changes in star clusters and in nebulæ, together with solutions more or less complete of many other questions that are now obscure to us. The material which we are now laboriously accumulating will then be available in reliable form to unravel the knowledge that is now beyond our grasp.

May I ask you, Mr. President, to accept these photographs for the library of the American Philosophical Society, with the best wishes of the Royal Astronomical Society of England; and, if you can make them available to those who are teaching the science among you, so that they may be able to make, say, lantern slides for lecture illustrations from them, they are entirely at your service, subject only to such restrictions as you and the Council may choose to exercise.

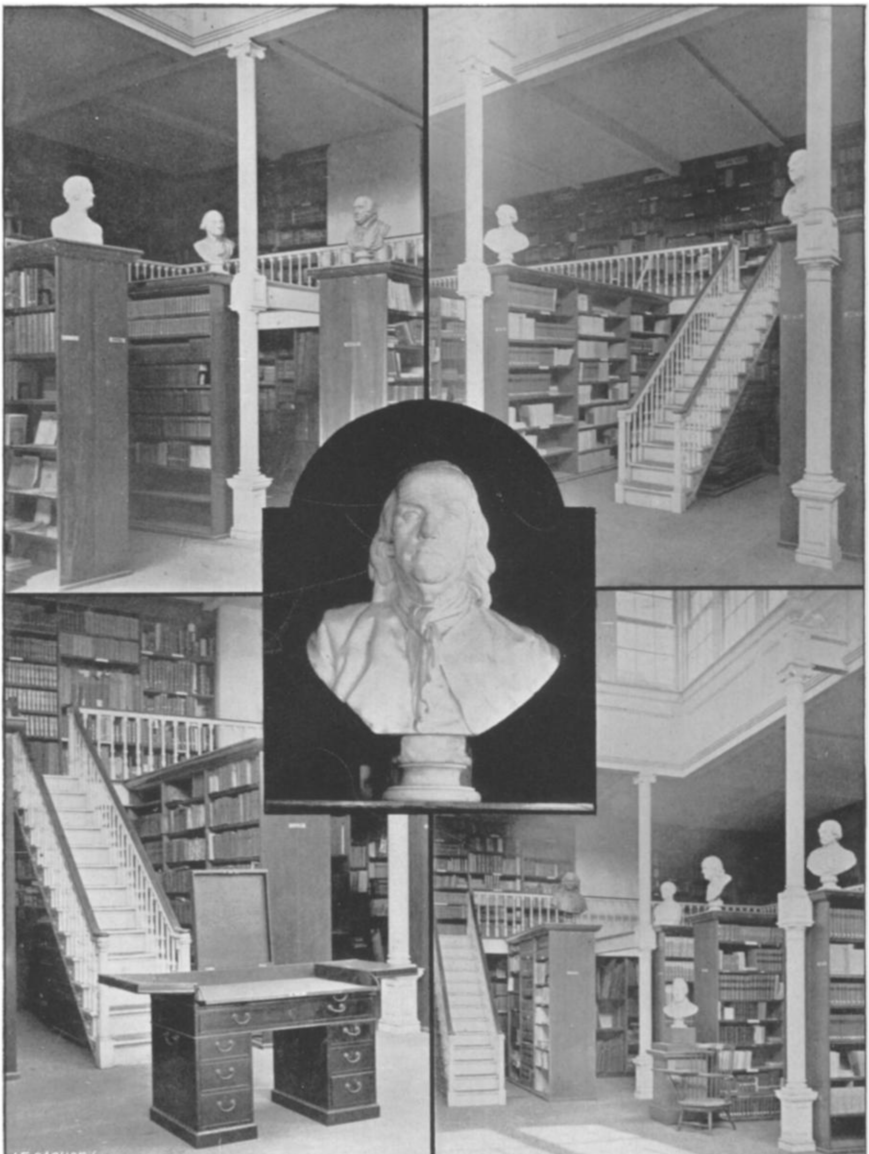
PRESIDENT FRALEY: I accept them on behalf of and with the thanks of the American Philosophical Society.

Prof. George F. Barker next read to the Society a paper on "Electrical Progress since 1743."

Mr. President and Gentlemen:—I take great pleasure in responding to the invitation of the Committee of Arrangements to prepare for the Sesquicentennial Anniversary of the American Philosophical Society a paper upon the development of electrical science since 1743, with especial reference to the part taken in this development by the members of this Society.

Surrounded as we are to-day with the numberless applications which have been made of electricity to the wants of man, it is not easy to go back one hundred and fifty years and to realize the actual condition of the science of electricity at that early date. It is true that Gilbert had already shown, in his remarkable book, *De Magnete*, published in 1600,* that "not only amber and agate attract small bodies, but diamond, sapphire, carbuncle, opal, amethyst, Bristol gem, beryl, crystal, glass, glass of antimony, spar of various kinds, sulphur, mastic and sealing wax" do so also. He had already invented the words, "electricity" and "electrical," and had differentiated between electric and magnetic forces by

* *De Magnete, Magneticisque Corporibus et de Magno magnete tellure*, Londini, Anno MDC.



VIEWS IN THE LIBRARY.

FRANKLIN (HOUDON)

showing that the electric force attracts all light bodies while the magnetic force attracts iron only. If, now, to these observations of Gilbert we add those of Von Guericke, in 1672,* that electrical repulsion exists as well as attraction ; of Boyle, the same year,† that the attraction between the electrified body and the light body is mutual; and that of Newton, in 1675,‡, that the electric action will pass through glass, we have before us an epitome of electric science at the close of the seventeenth century.

But the era of activity had begun. The light and sound of the electric spark were observed as early as 1708, by Wall,§ and their resemblance to lightning suggested. Hawksbee noticed, in 1709,|| the light which is produced when mercury is shaken in a glass tube, and had improved on the electrical machine of Von Guericke by using a globe of glass in place of one of sulphur. Gray, in 1729,¶ discovered the property of conduction, and divided bodies into *electrics per se* and *non-electrics* or *conductors*. Dufay discovered, in 1733, "that there are two kinds of electricity, very different from one another; one of which I call *vitreous*, the other *resinous*, electricity. The characteristic of these two electricities is that they repel themselves and attract each other." **

This, then, constituted substantially the whole of the electrical knowledge of the world when the American Philosophical Society was established. Franklin, himself, took up the subject a few years later. He tells us that, "in 1746, being at Boston, I met there with a Dr. Spence, who was lately arrived from Scotland, and showed me some electrical experiments. They were imperfectly performed, as he was not very expert; but, being on a subject quite new to me, they equally surprised and pleased me. Soon after my return to Philadelphia, our library company received from Mr. Peter Collinson, F.R.S., of London, a present of a glass tube, with some account of the use of it in making such experiments. I eagerly seized the opportunity of repeating what I had seen at Boston, and, by much practice, acquired great readiness in performing

* *Experimenta Magdeburgica*, Amsterdam, 1672, lib. iv, c. 15.

† *Boyle's Works*, Vol. iv, p. 352 (edition of 1772, published in London in six volumes).

‡ *Philosophical Transactions*, 1675. Wiedemann, "*Lehre von der Electricität*," Vol. i, p. 4, 1882.

§ *Phil. Trans.*, v, 409, 1708.

|| *Physico-mechanical Experiments*, 1709.

¶ *Phil. Trans.*, vii, 449, 1727.

** *Mémoires de l'Academie des Sciences*, 1733, p. 457.

those also which we had an account of from England, adding a number of new ones. I say much practice, for my house was continually full for some time with persons who came to see these new wonders. To divide a little this incumbrance among my friends, I caused a number of similar tubes to be blown in our glass house, with which they furnished themselves, so that we had, at length, several performers. Among these, the principal was Mr. Kinnersly, an ingenious neighbor, who, being out of business, I encouraged to undertake showing the experiments for money, and drew up for him two lectures in which the experiments were ranged in such order and accompanied with explanations in such method as that the foregoing should assist in comprehending the following. He procured an elegant apparatus for this purpose, in which all the little machines that I had roughly made for myself were neatly formed by instrument makers." * He continues: "Obliged as we were to Mr. Collinson for the present of the tube, etc., I thought it right he should be informed of our success in using it, and wrote him several letters containing accounts of our experiments."†

Franklin's first letter to Collinson is dated July 11, 1747. In it he says: "We rub our tubes with buckskin and observe always to keep the same side to the tube and never to sully the tube by handling; thus they work readily and easily, without the least fatigue, especially if kept in tight pasteboard cases, lined with flannel and fitting close to the tube." In a footnote he adds, "Our tubes are made here of green glass, 27 or 30 inches long, as big as can be grasped."

* *Memoirs of the Life and Writings of Benjamin Franklin, LL.D., F.R.S.* Written by himself to a late period and continued to the time of his death by his grandson, William Temple Franklin. Third edition, in six volumes. London, 1818. Vol. i, p. 237.

† *New Experiments and Observations on Electricity*, made at Philadelphia, in America, by Benjamin Franklin, LL.D and F.R.S. London, 1769. Franklin himself says of these letters: "Mr. Collinson gave them to *Cave* for publication in his *Gentlemen's Magazine;* but he chose to print them separately in a pamphlet and Dr. Fothergill wrote the Preface." In this Preface Dr. Fothergill says: "The experiments which our author relates are most of them peculiar to himself; they are conducted with judgment and the inferences from them plain and conclusive; though sometimes proposed under the terms of suppositions and conjectures. . . . .

"He exhibits to our consideration an invisible, subtle matter, disseminated through all nature in various proportions equally unobserved, and, whilst all those bodies to which it peculiarly adheres are alike charged with it, inoffensive.

"He shows, however, that if an unequal distribution is by any means brought about; if there is a coacervation in one part of space, a less proportion, vacuity or want in another; by the near approach of a body capable of conducting the coacervated part to the emptier space, it becomes, perhaps, the most formidable and irresistible agent in the universe. Animals are in an instant struck breathless, bodies almost impervious by any force yet known are perforated, and metals fused by it in a moment."

The precise form of the electrical machine used by Franklin appears to be a matter of some doubt. Parts of several machines are known, all reputed to have belonged to Franklin. Three or four quite similar frames are in existence, all provided with multiplying wheels for giving rotation to the electric used, which was mounted upon an axis placed above the wheel. One of these frames is in possession of the Franklin Institute, another is owned by the University of Pennsylvania, and a third is in the physical cabinet of the College of New Jersey, at Princeton. In only the first of these, however, is the electrical portion preserved. The electric is a glass globe, having a leather cushion for its rubber and provided with a curved rod for the collector. Moreover, these frames or stands all resemble very closely that which is described and figured as "the cylindrical machine as constructed by Franklin," in Snow Harris' *Frictional Electricity.** But, as shown, this latter machine is provided with a cylinder as the electric, and not a globe. Again, in January, 1879, Miss Mary D. Fox presented to the University of Pennsylvania several pieces of electrical apparatus, said to have belonged to Franklin, and to have been deposited at the house of her father, George Fox, at Champlost, to whom they were bequeathed by William Temple Franklin, the grandson of Benjamin Franklin, together with many of his valuable papers, now in possession of the American Philosophical Society.† One of these pieces of apparatus I have the pleasure of exhibiting. It is evidently the collector (or prime conductor, as it was formerly called) of an electrical machine; and, as is evident from its construction, could have been used only with a machine provided with a plate electric.

In the earliest electrical machine, made in 1672 by Von Guericke, the electric consisted of a globe of sulphur, mounted on a horizontal axis and rubbed with the hand. In 1709, Hawksbee replaced the sulphur globe by one of glass. Franklin, in his first letter to Collinson, thus speaks of his electrical machine: "Our spheres are fixed on iron axes which pass through them. At one end of the axis there is a small handle with which you turn the sphere like a common grindstone. This we find very commodious, as the machine takes up but little room, is portable and may be en-

* *A Treatise on Frictional Electricity in Theory and Practice*, by Sir William Snow Harris, F.R.S., London, 1867, p. 104.

† See *Proceedings Amer. Philos. Soc.*, i, 253, July 17, 1810. "The Franklin papers were bequeathed by will to George Fox, father of C. P. Fox, by Temple Franklin, grandson of Benjamin Franklin."

closed in a tight box when not in use. 'Tis true the sphere does not turn so swift as when the great wheel is used; but swiftness we think of little importance, since a few turns will charge the vial sufficiently." He adds, in a footnote: "This simple and easily made machine was a contrivance of Mr. Syng's."

The addition of a metallic collector to the globe machine was made by Boze in 1742,* and the use of a leather cushion as the rubber was introduced by Winkler in 1744.† And, although Hawksbee had used a cylindrical electric, yet it did not come into use apparently until Wilson again made use of it in 1752.‡ It was not until 1756 that De la Fond § made a machine having a plate electric; in which he was closely followed by Ingenhaus (1764),‖ Cuthbertson (1770),¶ and Le Roy (1772).** The addition of a multiplying wheel is generally attributed to Nollet, in 1746.††

In this connection, it is interesting to note that, with the electrical apparatus given to the University by Miss Fox, there was a set of copper-plate impressions of certain experiments in heat and electricity. As these engravings could not be identified with any of the researches made by Franklin, it was for some time doubtful what their origin was and what their connection with Franklin himself. Finally, several years later, in looking over the very complete antiquarian scientific library of Prof. H. Carrington Bolton, of New York, the writer observed that *facsimiles* of these plates served as the illustrations of a book entitled, "*Recherches Physiques sur le Feu.* Par M. Marat, Docteur en Médecine et Médecin des Gardes du Corps de Monseigneur le Comte d'Artois. À Paris, Rue Dauphine, MDCCLXXX, pp. 204 avec VI planches." Thus establishing the fact of scientific intercourse between Franklin and Marat, afterwards one of the chief actors in the French Revolution.‡‡

* *Die Electricität nach ihrer Entdeckung und Forgang*, etc., Wittenberg, 1744.

† *Gedanken von den Eigenschaften . . . . nebst Beschreibung zweyer neuen electrischen Maschinen*, Leipzig, 1744.

‡ *A Treatise on Electricity*, London, 1752.

§ *Précis des Phénomènes Électriques*, 1756, 2d ed., p. 47.

‖ *Phil. Trans.*, xiv, 598, 1779.

¶ Harris' *Frictional Electricity*, p. 68.

** *Mémoires de l'Academie*, Première Partie, p 499, 1772.

†† *Leçons de Physique*, Paris, 1767.

‡‡ In a memorandum made at Passy, December 13, 1778, Franklin says: "Received a parcel from an unknown philosopher [afterwards discovered to be *Marat*, of subsequent notorious memory], who submits to my consideration a memoir on the subject of *elementary fire*, containing experiments in a dark chamber. It seems to be well written, and is in English, with a little tincture of French idiom. I wish to see the experiments, without which I cannot well judge of it" (*Memoirs*, Vol. ii, p. 90).

It appears, then, that in scarcely more than a year Franklin had mastered the theory and practice of electrical science and had become an investigator. In his letter to Collinson of July 11, 1747, he describes an experiment showing "the wonderful effect of pointed bodies both in *drawing off* and in *throwing off* the electrical fire." Moreover, it is in this first scientific letter that he propounds his theory of electricity. "We say B (and bodies like circumstanced) is electrified *positively;* A, *negatively.* Or, rather, B is electrified *plus;* A, *minus.* And we daily, in our experiments, electrize bodies *plus* or *minus,* as we think proper. To electrize *plus* or *minus,* no more needs to be known than this, that the parts of the tube or sphere that are rubbed do, in the instant of the friction, attract the electrical fire and therefore take it from the thing rubbing; the same parts, immediately as the friction upon them ceases, are disposed to give the fire they have received to any body that has less."

In 1745, Kleist,* and, in 1746, Cuneus,† had observed the phenomena of electrical condensation, and Muschenbroek had constructed the Leyden jar. The experiments of Franklin, made in 1747, showed that "at the same time that the wire and top (inside) of the bottle is electrified *positively* or *plus,* the bottom of the bottle (outside) is electrified *negatively* or *minus* in exact proportion; *i. e.,* whatever quantity of electrical fire is thrown in at top, an equal quantity goes out of the bottom." "None can be thrown into the top when none can get out at the bottom." . . . . "Again, when the bottle is electrified, but little of the electrical fire can be *drawn out* at the top by touching the wire unless an equal quantity can at the same time *get in* at the bottom." By these and similar experiments he completely analyzed the phenomena in question. He continues: "So wonderfully are these two states of electricity, the *plus* and *minus,* combined and balanced in this miraculous bottle, situated and related to each other in a manner that I can by no means comprehend! If it were possible that a bottle should in one part contain a quantity of air strongly comprest, and in another part a perfect vacuum, we know that the equilibrium would be instantly restored *within.* But here we have a bottle containing at the same time a *plenum* of electrical fire and a vacuum of the same fire; and yet the equilibrium cannot be restored between them but

* *Versuche u. Abh. d. Naturf. Gesellsch.,* Danzig, 1745, Vol. ii, p. 408.

† *Mémoires de l'Academie des Sciences,* 1746, p. 2.

by a communication without; though the *plenum* presses violently to expand and the hungry vacuum seems to attract as violently in order to be filled."

Again, Franklin was the first to prove that the phenomena of condensation have their seat in the dielectric and not in the metallic coatings. "The whole force of the bottle and power of giving a shock," he says, "is in THE GLASS ITSELF; the non-electrics, in contact with the two surfaces, serving only to *give* and *receive* to and from the several parts of the glass; that is, to give to one side and take away from the other." This opinion he supports by striking and conclusive experiments. "It is amazing," he continues, "to observe in how small a portion of glass a great electrical force may lie. A thin glass bubble, about an inch diameter, weighing only six grains, being half filled with water, partly gilt on the outside and furnished with a wire hook, gives, when electrified, as great a shock as a man can well bear. As the glass is thickest near the orifice, I suppose the lower half—which, being gilt, was electrified and gave the shock—did not exceed two grains; for it appeared, when broke, much thinner than the upper half." . . . . "Allowing that there is no more electrical fire in a bottle after charging than before, how great must be the quantity in this small portion of glass! It seems as if it were of its very substance and essence. Perhaps if that due quantity of electrical fire, so obstinately retained by glass, could be separated from it, it would no longer be glass; it might lose its transparency, or its brittleness, or its elasticity. Experiments may possibly be invented hereafter to discover this." Can we state to-day, in any clearer language, the electrical condition in the Leyden jar?

At the close of this investigation, he writes as follows: "Chagrined a little that we have been hitherto able to produce nothing in this way of use to mankind; and the hot weather coming on, when electrical experiments are not so agreeable, it is proposed to put an end to them for this season somewhat humorously in a party of pleasure on the banks of *Skuylkil.* Spirits, at the same time, are to be fired by a spark sent from side to side through the river, without any other conductor than the water; an experiment which we some time since performed to the amazement of many. A turkey is to be killed for our dinner by the *electrical shock* and roasted by the *electrical jack* before a fire kindled by the electrified bottle; when the healths of all the famous electricians in *England*, *Holland*,

France and *Germany* are to be drank in *electrified bumpers* under the discharge of guns from the *electrical battery*."

It was in 1749 that Franklin came to the conclusion that lightning and the electrical fire are identical. "To determine the question," he says,* "whether the clouds that contain lightning are electrified or not, I would propose an experiment to be try'd where it may be done conveniently. On the top of some high tower or steeple place a kind of centry box big enough to contain a man and an electrical stand. From the middle of the stand let an iron rod rise and pass, bending, out of the door and then upright twenty or thirty feet, pointed very sharp at the end. If the electrical stand be kept clean and dry, a man, standing on it when such clouds are passing low, might be electrified and afford sparks, the rod drawing fire to him from a cloud. If any danger to the man should be apprehended (though I think there would be none), let him stand on the floor of his box and now and then bring near to the rod the loop of a wire that has one end fastened to the leads, he holding it by a wax handle; so the sparks, if the rod is electrified, will strike from the rod to the wire and not affect him."

On the 10th of May, 1752, M. D'Alibard, the translator of Franklin's letters to Collinson, placed in a garden at Marly, near Paris, a pointed bar of iron, forty feet high, supported upon an electrical base. At twenty minutes past two in the afternoon, a storm cloud passed over the rod, and the observers drew sparks from it and obtained with it all the common electrical phenomena.†

Shortly after, M. DeLor, who had repeated many of Franklin's experiments before the king, Louis XV, raised at his house, in Paris, a bar of iron ninety-nine feet high, placed upon a cake of resin two feet square and three inches thick. On the 18th of May between four and five in the afternoon, a storm cloud passed over the bar, and M. DeLor drew sparks from the bar which produced the same noise, the same fire, and the same crackling; the longest of these sparks being nine lines.

On July 20, Canton erected upon his house in London, a tin tube between three and four feet in length, fixed to the top of a glass one of about eighteen inches. To the upper end of the tin tube, which was not so high as a stack of chimnies on the same

* *New Observations and Experiments on Electricity*, p. 66.

† See the letter of the Abbe Mazeas, *New Experiments and Observations on Electricity*, p. 107.

house, he fastened three needles with some wire; a tin cover being soldered to the lower end to keep the rain from the glass tube, which was set upright in a block of wood. No electrification appeared upon this apparatus during the storm until after the third thunder-clap. Then, on applying his knuckle to the edge of the cover, Canton felt and heard an electrical spark, the length of which was about half an inch; the experiment being repeated four or five times in the space of a minute.

On August 12, Mr. Wilson, of Chelmsford, in Essex, during a thunder-storm, about noon, observed several electrical snaps from an iron curtain rod, one end of which he had put into the neck of a glass phial held in the hand, and to the other end of which he had fastened three needles. The sparks were taken from the rod to the finger of one hand, the other hand supporting the rod.

In communicating these experiments of Canton and Wilson to the Royal Society,* Watson says: "After the communications which we have received from several of our correspondents in different parts of the continent, acquainting us with the success of their experiments last summer in endeavoring to extract the electricity from the atmosphere during a thunder-storm, in consequence of Mr. Franklin's hypothesis, it may be thought extraordinary that no accounts have been yet laid before you of our success here from the same experiments." And he then proceeds to state that, "though several members of the Royal Society, as well as myself, did, upon the first advices from *France*, prepare and set up the necessary apparatus for this purpose," they were defeated in their expectations because of the uncommon coolness and dampness of the air in London; only one thunder-storm, that of July 20, having occurred during the season.

The celebrated kite experiment was made during the summer of 1752, in Philadelphia. Dr. Franklin, himself, thus describes it: "Make a small cross of two light strips of cedar, the arms so long as to reach to the four corners of a large, thin silk handkerchief when extended; tie the corners of the handkerchief to the extremities of the cross, so you have the body of the kite; which, being properly accommodated with a tail, loop and string, will rise in the air like those made of paper; but this, being of silk, is fitter to bear the wet and wind of a thunder gust without tearing. To

* *Phil. Trans.*, xlvii, 1752. See also *New Experiments and Observations on Electricity*, p. 109.

the top of the upright stick of the cross is to be fixed a very sharp-pointed wire, rising a foot or more above the wood. To the end of the twine, next the hand, is to be tied a silk ribbon, and where the silk and twine join a key may be fastened. This kite is to be raised when a thunder gust appears to be coming on, and the person who holds the string must stand within a door or window, or under some cover, so that the silk ribbon may not be wet; and care must be taken that the twine does not touch the frame of the door or window. As soon as any of the thunder clouds come over the kite, the pointed wire will draw the electric fire from them, and the kite, with all the twine, will be electrified, and the loose filaments of the twine will stand out every way and be attracted by an approaching finger. And when the rain has wet the kite and twine so that it can conduct the electric fire freely, you will find it stream out plentifully from the key on the approach of your knuckle. At this key the phial may be charged; and, from electric fire thus obtained, spirits may be kindled and all the other electric experiments be performed which are usually done by the help of a rubbed glass globe or tube, and thereby the sameness of the electric matter with that of lightening completely demonstrated." *

"In September, 1752, I erected an iron rod to draw the lightening down into my house," Franklin writes to Collinson, a year later, "in order to make some experiments on it with two bells, to give notice when the rod should be electrify'd, a contrivance obvious to every electrician. I found the bells rang sometimes when there was no lightning or thunder, but only a dark cloud over the rod; that sometimes, after a flash of lightning, they would suddenly stop, and at other times, when they had not rang before, they would, after a flash, suddenly begin to ring; that the electricity was sometimes very faint, so that when a small spark was obtain'd another could not be got for some time after; at other times the sparks would follow extremely quick; and once I had a continual stream from bell to bell the size of a crow quill. Even during the same gust there were considerable variations." The following winter he charged two phials, one with lightning from the iron rod, the other, equally, by the electric glass globe, and suspended a cork ball between the wires issuing from the top. He observed the cork ball play briskly between them, proving the

**New Experiments and Observations on Electricity*, p. 111. Letter of date October 19, 1752

charge from the clouds to be negative. Subsequent experiments showed that while in general the charge from the clouds is negative, it is sometimes positive.

In 1749, Franklin applied his knowledge of the power of points to the practical protection of buildings. He says: "If those things are so [*i. e.*, 'if the fire of electricity and that of lightning be the same'] may not the knowledge of this power of points be of use to mankind in preserving houses, churches, ships, etc., from the stroke of lightning by directing us to fix on the highest points of those edifices upright rods of iron, made sharp as a needle, and gilt to prevent rusting, and from the foot of those rods a wire down the outside of the building into the ground, or down round one of the shrouds of a ship and down her side till it reaches the water? Would not these pointed rods probably draw the electrical fire silently out of a cloud before it came nigh enough to strike, and thereby secure us from that most sudden and terrible mischief?"

In 1753, Franklin formally recommended that pointed rods be placed on buildings to prevent their being struck by lightning. But the suggestion does not seem to have come very rapidly into favor, since in a subsequent letter to Kinnersley, written from London, in 1762, Franklin says: "You seem to think highly of the importance of this discovery, as do many others on our side of the water. Here it is very little regarded; so little that though it is now seven or eight years since it was made public, I have not heard of a single house as yet attempted to be secured by it."* In 1777, at a meeting of the Royal Society Wilson protested against the pointed conductors of Franklin, and endeavored to prove the superior advantages of knobs to points, and the greater safety to be derived from blunt as compared with sharp lightning conductors. His experiments attracted considerable attention and evoked sharp discussion; and during this discussion "the pointed lightning conductors were taken down from the queen's palace." † They were never replaced, notwithstanding the condemnation of the pretended improvement by the Royal Society in their reports in favor of pointed conductors, and their being consequently generally employed for the protection of the powder magazines throughout the country. On being urged to reply to Wilson's assertions, Franklin

* *New Experiments and Observations on Electricity*, p. 416.

† *Memoirs*, Vol. ii, p. 79.

replied: "I have never entered into any controversy in defense of my philosophical opinions. I leave them to take their chance in the world. If they are *right*, truth and experience will support them; if *wrong*, they ought to be refuted and rejected. Disputes are apt to sour one's temper, and disturb one's quiet. I have no private interest in the reception of my inventions by the world, having never made, nor propose to make, the least profit by any of them. The king's changing his pointed conductors for blunt ones is, therefore, a matter of small importance to me. If I had a wish about it, it would be that he had rejected them altogether as ineffectual. For it is only since he thought himself and family safe from the thunder of heaven that he dared to use his own thunder in destroying his innocent subjects."*

These scientific and political conditions acting together, gave rise to the well-known and pointed epigram:

"While you, Great George, for safety hunt,
And sharp conductors change for blunt,
The empire's out of joint.
Franklin a wiser course pursues,
And all your thunder fearless views
By keeping to the *point*."

It was in recognition of the importance and value of Franklin's electrical investigations that the Royal Society not only elected him a member of that learned body, but also awarded to him the Copley gold medal. †

Of similar interest are Franklin's experiments on the physiologi-

* *Memoirs*, Vol. ii, p 81.

† Franklin's own account of the action of the Royal Society is as follows: "Dr. Wright, an English physician, when at Paris, wrote to a friend who was of the Royal Society an account of the high esteem my experiments were in among the learned abroad, and of their wonder that my writings had been so little noticed in England. The Society on this resumed the consideration of the letters that had been read to them; and the celebrated Dr. Watson drew up a summary account of them and of all I had afterwards sent to England on the subject; which he accompanied with some praise of the writer. This summary was then printed in their Transactions; and some members of the Society in London, particularly the very ingenious Mr. Canton, having verified the experiment of procuring lightning from the clouds by a pointed rod, and acquainted them with the success, they soon made me more than amends for the slight with which they had before treated me. Without my having made any application for that honor, they chose me a member, and voted that I should be excused the customary payments, which would have amounted to twenty-five guineas; and ever since have given me their Transactions gratis. They also presented me with the gold medal of Sir Godfrey Copley for the year 1753, the delivery of which was accompanied by a very handsome speech of the President, Lord Macclesfield, wherein I was highly honored" (*Memoirs*, Vol. i, p. 241).

cal action of the electric discharge. In a letter to the Royal Society he gives an account of these experiments.* "He made first several experiments on fowls, and found that two large, thin glass jars gilt, holding each about six gallons, were sufficient, when fully charged, to kill common hens outright; but the turkeys, though thrown into violent convulsions, and then lying as dead for some minutes, would recover in less than a quarter of an hour. However, having added three other such to the former two, though not fully charged, he killed a turkey of about ten pounds weight, and believes that they would have killed a much larger. He conceited, as himself says, that the birds killed in this manner eat uncommonly tender." "In making these experiments he found that a man could, without great detriment, bear a much greater shock than he had imagined; for he inadvertently received the stroke of two of these jars through his arms and body, when they were very nearly fully charged. It seemed to him an universal blow throughout the body from head to foot, and was followed by a violent, quick trembling in the trunk, which went off gradually in a few seconds. It was some minutes before he could recollect his thoughts, so as to know what was the matter; for he did not see the flash, though his eye was on the spot of the prime conductor from whence it struck the back of his hand; nor did he hear the crack, though the bystanders said it was a loud one; nor did he particularly feel the stroke on his hand, though he afterward found it had raised a swelling there of the bigness of half a pistol bullet. His arms and the back of the neck felt somewhat numbed the remainder of the evening, and his breast was sore for a week after, as if it had been bruised. From this experiment may be seen the danger, even under the greatest caution, to the operator, when making these experiments with large jars, for it is not to be doubted but several of these fully charged would as certainly, by increasing them in proportion to the size, kill a man as they before did a turkey."

With reference to the practical application of these experiments, Franklin subsequently wrote the following letter to MM. Dubourg and D'Alibard: † "My answer to your questions concerning the mode of rendering meat tender by electricity, can only be founded upon conjecture; for I have not experiments enough to warrant the

* *New Experiments and Observations*, p. 253.

† *Memoirs*, Vol. vi, p. 228.

facts. All that I can say at present is that I think electricity might be employed for this purpose; and I shall state what follows as the observations or reasons which make me presume so. It has been observed that lightning by rarefying and reducing into vapor the moisture contained in solid wood, in an oak for instance, has forcibly separated its fibres and broken it into small splinters; that by penetrating completely the hardest metals, as iron, it has separated the parts in an instant so as to convert a perfect solid into a state of fluidity; it is not then improbable that the same subtile matter passing through the bodies of animals with rapidity should possess sufficient force to produce an effect nearly similar.

"The flesh of animals killed in the usual manner is firm, hard, and not in a very eatable state because the particles adhere too forcibly to each other. At a certain period the cohesion is weakened, and in its progress towards putrefaction, which tends to produce a total separation, the flesh becomes what we call tender, or is in that state most proper to be used as our food.

"It has frequently been remarked that animals killed by lightning putrefy immediately. This cannot be invariably the case, since a quantity of lightning sufficient to kill may not be sufficient to tear and divide the fibres and particles of flesh, and reduce them to that tender state which is the prelude to putrefaction. Hence it is that some animals killed in this manner will keep longer than others. But the putrefaction sometimes proceeds with surprising celerity. A respectable person assured me that he once knew a remarkable instance of this. A whole flock of sheep in Scotland being closely assembled under a tree, were killed by a flash of lightning; and it being rather late in the evening, the proprietor, desirous of saving something, sent persons early the next morning to flay them; but the putrefaction was such and the stench so abominable that they had not the courage to execute their orders, and the bodies were accordingly buried in their skins. It is not unreasonable to presume that between the period of their death and that of their putrefaction a time intervened in which the flesh might be only tender, and only sufficiently so to be served at table. Add to this that persons who have eaten of fowls killed by our feeble imitation of lightning (electricity) and dressed immediately, have asserted that the flesh was remarkably tender. . . .

"As this kind of death is nevertheless more sudden and consequently less severe than any other, if this should operate as

a motive with compassionate persons to employ it for animals sacrificed for their use, they may conduct the process thus:

"Having prepared a battery of six large glass jars (each from twenty to twenty-four pints) as for the Leyden experiment, and having established a communication as usual from the interior surface of each with the prime conductor; and having given them a a full charge (which, with a good machine, may be executed in a few minutes, and may be estimated by an electrometer), a chain which communicates with the exterior of the jars must be wrapped round the thighs of the fowl; after which the operator, holding it by the wings turned back and made to touch behind, must raise it so high that the head may receive the first shock from the prime conductor. The animal dies instantly. Let the head be immediately cut off to make it bleed, when it may be plucked and dressed immediately. This quantity of electricity is supposed sufficient for a turkey of ten pounds weight, and perhaps for a lamb. Experience alone will inform us of the requisite proportions for animals of different forms and ages. Probably not less will be required to render a small bird which is very old tender than for a larger one which is young. It is easy to furnish the requisite quantity of electricity by employing a greater or less number of jars. As six jars, however, discharged at once are capable of giving a very violent shock, the operator must be very circumspect lest he should happen to make the experiment on his own flesh instead of that of the fowl."

Franklin's experiments upon the effect of the electric discharge upon the human subject he thus describes in a letter to a friend in Charleston, S. C., written in 1755: * "The knocking down of the six men was performed with two of my large jars not fully charged. I laid one end of my discharging rod upon the head of the first; he laid his hand on the head of the second; the second his hand on the head of the third; and so to the last, who held in his hand the chain that was connected with the outside of the jars. When they were thus placed, I applied the other end of my rod to the prime conductor and they all dropt together. When they got up they all declared they had not felt any stroke, and wondered how they came to fall; nor did any of them either hear the crack or see the light of it. You suppose it is a dangerous experiment; but I had once suffered the same myself, receiving by accident an equal stroke

* Letters and Papers on Philosophical Subjects. *New Experiments and Observations on Electricity*, p. 324.

through my head that struck me down without hurting me. And I had seen a young woman that was about to be electrified through the feet (for some indisposition) receive a greater charge through the head by inadvertently stooping forward to look at the placing of her feet, till her forehead (as she was very tall) came too near my prime conductor: She dropt, but instantly got up again complaining of nothing. A person so struck sinks down doubled or folded together as it were, the joints losing their strength and stiffness at once, so that he drops on the spot where he stood, instantly, and there is no previous staggering, nor does he ever fall lengthwise. Too great a charge might indeed kill a man, but I have not yet seen any hurt done by it. It would certainly, as you observe, be the easiest of all deaths."

If the condition of electrostatic science when the American Philosophical Society was founded was as primitive as we have above pointed out, that of the other departments of electricity was far more so. Galvani had not observed the twitching of the frog's legs as, suspended by a copper wire, they swung to and fro against the iron railing of his laboratory balcony. Volta had not made his important discovery that the contact of two metals developed electrification; and hence had not at this time constructed his celebrated pile. True, metals had been fused by the discharge of the electric battery, needles had been magnetized by it, and animals had been shocked and even killed by it, as in the experiments made by Franklin and others soon after 1743. But now various other modes of electrification were to be discovered and coördinated and the identity of the result, by whatsoever means obtained, was to be experimentally established.

Among the members of this Society whose names appear prominent as investigators in these new fields we should mention Robert Hare, Joseph Henry, Joseph Saxton, David Rittenhouse and Alexander Dallas Bache.

Robert Hare was elected a member of the American Philosophical Society in 1803. In 1821 he published an important paper "On Some New Modifications of Galvanic Apparatus." * In this paper he states that he had observed that, while the maximum effect of a single galvanic pair was reached as soon as the plates were immersed in the liquid, a series of troughs which had to be succes-

* *Amer. Jour. Science and Arts*, iii, 105, 1821.

sively immersed never reached their maxima together, the effect of the earlier ones being lost before that of the later ones came on. In order to remedy this difficulty, he prepared eighty concentric coils of copper and zinc plates and attached them to a system of levers so that they could be simultaneously immersed. The zinc sheets were nine inches by six in size, and the copper sheets fourteen inches by six, a quarter of an inch interval being left between them. Each pair, as rolled up, was two and a half inches in diameter, and eighty glass jars were arranged to receive the eighty coils of plates when they were lowered. A piece of charcoal a quarter of an inch thick and one and a half inches long was inserted between the ends of the lead pipes which served as conductors. On lowering the plates "no vestige of the charcoal could be seen. It was ignited so intensely that those portions of the pipes by which it had been embraced were destroyed."

He then had a trough constructed having a partition through the middle. In this trough he placed the eighty coils, forty of them being on each side of the partition. Although, when in action, this battery produced only a moderate sensation, and did not ignite charcoal as easily, a most intense ignition took place whenever a metallic point on one pole was brought in contact with a piece of charcoal on the other. And when a cylinder of platinum, nearly a quarter of an inch in diameter and tapering a little at the end, was placed in the circuit, it was at once fused and burned so as to sparkle to a considerable distance around and to fall in drops. When the two troughs were separated by an interval of four inches, so as to improve the insulation, charcoal was so vividly ignited that the eyes of the experimenter were affected for forty-eight hours, the charcoal assuming a pasty consistence.

In accordance with the theory which he had propounded in 1818,* Dr. Hare explained these differences in effect by the hypothesis that the fluid extricated by Volta's pile is a compound of caloric and electricity. According to this theory, "the galvanic fluid," he says, "owes its properties to caloric and electricity, the former predominating in proportion to the size of the pairs, the latter in proportion to the number, being in both cases excited by a powerful acid. Hence in batteries which combine both qualifications sufficiently, as in all those intervening between Children's large

* *Amer. Jour. Science and Arts*, i, 413, 1818.

pairs of two feet eight inches by six feet and the two thousand four-inch pairs of the Royal Institution, the phenomena indicate the presence of both fluids. In De Luc's column, where the size of the plates is insignificant and the energy of interposed agents feeble, we see electricity evolved without any appreciable quantity of caloric. In the calorimotor, where we have size only, the number being the lowest possible, we are scarcely able to detect the presence of electricity. When the fluid contains enough electricity to give a projectile power adequate to pass through a small space in the air, or through charcoal, which impedes or arrests the caloric and favors its propensity to radiate this principle, heat is evolved. This accounts for the evolution of intense heat under those circumstances which rarefy the air, so that the length of the jet from one pole to the other may be extended after its commencement. Hence, the portions of the circuit nearest to the intervening charcoal or heated space are alone injured; and even non-conducting bodies, as quartz, introduced into it are fused, and hence a very large wire may be melted by the fluid received through a small wire imperceptibly affected."

To these two forms of galvanic generators, which differed as materially in the effects which they produced as they did in their construction, Dr. Hare gave the names "calorimotor" and "deflagrator." The calorimotor was constructed first in 1818. He was led to this form of instrument by reflecting that, "as the number of pairs in Volta's pile had been extended, and their size and the number and energy of interposed agents lessened, the ratio of the electrical effects to those of heat had increased till, in De Luc's column, they had become completely predominant; and, on the other hand, when the pairs were made larger and fewer (as in Children's apparatus) the calorific influence had gained the ascendency; he was, therefore, led to go farther in this way and to examine whether one pair of plates of common size, or what might be equivalent thereto, would not exhibit heat more purely and demonstrate it to be, equally with the electric fluid, a primary product of Galvanic combinations."* This conception he put into practice by constructing a single galvanic pair, consisting of twenty copper plates, each about nineteen inches square, all soldered to the same metallic bar, so as to constitute, electrically, a single copper plate,

* *Amer. Jour. Science and Arts*, i, 416, July, 1818.

alternating, at intervals of half an inch, with twenty similar zinc plates, all united to another metallic bar. He found, on immersing these plates in the same portion of acid contained in a vessel without partitions, that, while a wire connecting the poles was intensely ignited, only a slight taste was produced on the tongue, not greater than that produced by a piece of silver and one of zinc an inch square. Hence he concluded that when the plates are arranged without alternation the effect is no greater than might be expected from one pair of plates. He then caused ten of the zinc plates on the one side to be connected with ten of copper on the other, the ten remaining plates of the same name on each side being connected with each other; the connection between these large plates, one of copper and the other of zinc, being effected by a wire. When these two alternating pairs were plunged in acid, in a common vessel without partitions, the wire became vividly ignited. Substantially, this arrangement was adopted in the construction of a large calorimotor ordered by Prof. Silliman for the laboratory of Yale College and made under Dr. Hare's direction. The plates were eighteen inches square; nine of zinc, on one side, alternated with ten of copper, and ten of zinc, on the other side, alternated with eleven of copper; the entire forty plates having in all ninety square feet of surface. The plates of the same name were connected by large bars of tin, the whole being supported on a balanced frame so as to be lowered readily into a cubical box without partitions. "This instrument," says Prof. Silliman, "gives no shock, produces no chemical decompositions, and does not move the gold-leaf electrometer, nor does it ignite charcoal points, however small, although in close contact, or strike through the smallest layer of air to pass even to the best conductor. But when any metallic substance with a bright surface is brought into perfect contact, by screwing it firmly into the jaws of the vices that terminate its poles, and the plates are then immersed in the acid, intense ignition follows and combustion also, if the metal is combustible in common air. Platinum wire is instantly ignited and melted, a large steel knitting needle is destroyed before the plates are half immersed, and, by a full immersion, iron nails of the size called ninepenny and tenpenny are ignited and burn vividly till the connection is destroyed by burning in two."* Further, it was observed that the calorimotor produced fine magnetic effects.

* *Elements of Chemistry*, Vol. ii, p. 670, New Haven, 1831.

The deflagrator of Dr. Hare was first described in 1821,* and as above mentioned consisted of eighty concentric coils of copper and zinc, each coil having its glass jar of acid; the coils being attached to a common beam which was raised and lowered by means of levers. Subsequently he adopted the form of flat, hollow, copper cases into which the zinc plates were made to slide, being secured in their places and prevented from actual contact with the copper by grooved pieces of wood which receive the edges of the zinc and rest against the inside of the copper cases; each zinc plate being connected to the next copper case by a metallic strip. These cases were supported in frames and well insulated from one another, these frames being movable and capable of being lowered into the troughs containing the acid, or being stationary, and the troughs raised in order to immerse the plates. This construction was the one adopted in the deflagrator made by Dr. Hare for the laboratory of Yale College. In his last form of instrument, called the Cruikshank deflagrator, the copper and zinc plates, soldered together in pairs at their edges, were fixed in a box supported on pivots; so that by rotating it through 90°, the acid surrounding the plates flowed into a second and similar box attached to the first and at right angles to it. By reversing the motion the acid flowed again upon the plates.† "Both in producing ignition and combustion," says Prof. Silliman, "the deflagrators far surpass any other form of galvanic instruments. Combustion is exceedingly vivid; the metallic leaves vanish in splendid coruscations; a platinum wire several feet in length fixed between the poles while the metals are in the air becomes red and white hot, and melts the instant they are immersed; the largest wire of this metal fixed in one pole and touched to charcoal in the other, melts like wax in a candle and is dissipated in brilliant scintillations; a watch-spring or a large steel knitting-needle fixed in the same manner and touched to the charcoal point burns completely away with a torrent of light and sparks; a stream of mercury flowing from a funnel is deflagrated with brilliant light, and an iron wire is fused and welded to another under water." ‡ It was with this instrument that Prof. Silliman, in 1821, observed for the first time the transfer of the carbon from the positive to the negative pole, this carbon rapidly collecting on the negative side into a

* *Amer. Jour. Science and Arts*, Vol, iii, p. 105, 1821.

† *Amer. Jour. Science and Arts*, Vol. vii, 347 (1824); Vol. xxxii, 285 (1837).

‡ *Elements of Chemistry*, Vol. ii, p. 672, 1831.

knob or projecting cone or cylinder, which frequently becomes half an inch or more long before it falls and gives place to another. On the positive pole a corresponding cavity is formed, out of which the vaporized matter rises and collects upon the negative pole. The carbon thus deposited "is in shining, rounded masses, aggregated often like a cauliflower. It has a semi-metallic appearance, is harder than the charcoal, heavier, much less combustible, and burns away slowly when ignited in the air."

In the light of the electrical science of those days, these constructions by Dr. Hare, the results obtained by their means and the theories which he offered in explanation of the phenomena, are all of very considerable interest. The principal effect of the calorimotor, obviously, was to produce a great flow of heat with very little electrical excitement. But experiment had pointed out that not only alternation of the plates but a repetition of the pairs to at least two was necessary to produce an intense calorific effect; the quantity being as the size and the intensity as the number of the series. True, Davy had shown in 1808 this necessity of repetition, and had stated that "the intensity increases with the number and the quantity with the extent of the series." * And Children the following year † had confirmed this view and elaborated it. "The absolute effect of a voltaic apparatus," he says, "seems to be in the compound ratio of the number and size of the plates, the intensity of the electricity being as the former, the quantity given out as the latter; consequently regard must be had in its construction to the purposes for which it is designed. For experiments on perfect conductors very large plates are to be preferred, a small number of wicks will probably be sufficient; but where the resistance of imperfect conductors is to be overcome the combination must be great but the size of the plates may be small; but if quantity and intensity be both required, then a large number of large plates will be necessary." It should be remembered, moreover, that the law of Ohm was not enunciated until 1827,‡ and that of Joule not until 1841.§ And, further, that we owe to these laws the simplification of the ideas upon the subject of the energy relations of electricity which existed before they were discovered. Ohm's law teaches us that the

* *Philosophical Transactions*, 1808, p. 3.

† *Ib.*, Vol. ix, p. 32 (1809).

‡ *Die galvanische Kette mathematisch bearbeitet*, Berlin, 1827.

§ *Phil. Mag.*, xix, p. 260 (1841).

current which flows through any circuit depends directly upon the electromotive forces contained in the circuit and inversely upon the resistances of the circuit. Evidently, therefore, when a considerable resistance is to be overcome, as when a long, fine wire is in circuit, the current necessary to fuse this wire, for example, can be secured only by increasing proportionately the electromotive force, *i. e.*, by increasing the number of pairs in series in the battery. While, when the external resistance is small, as is the case when a large metallic wire joins the terminals, very little electromotive force, and therefore only a few pairs, is required; but by making the plates large the resistance of the battery is diminished, and so the current in the entire circuit is increased. In the deflagrator then, the result was attained by increasing the number of the plates in order to secure a high electromotive force. In the calorimotor the size was increased in order to decrease the total resistance and so to increase the current. Again, the law of Joule gives us the relation between the amount of current flowing through a circuit and the development of heat in it; asserting that the heat thus developed is directly proportional to the resistance in the circuit and to the square of the current. Consequently the heating effects of Dr. Hare's calorimotor are due to the large current which it was the object of its construction to produce. While in the deflagrator, although the current is less, and therefore the total heating effect is less also, yet the current is urged by a greater pressure and hence exerts a greater disruptive effect. Another point should be noted in connection with these distinctions thus emphasized in Dr. Hare's generators. Electrical energy may be represented by the product of the current and the electromotive force. To transmit a given amount of this energy to a distance, either a strong current having a low electromotive force may be employed, or a weak current having a high electromotive force, provided the product be the same in both cases. But by the law of Joule, the energy dissipated as heat, being proportional to the square of the current, would entail a serious loss in the former case. Hence the economical transmission of electrical energy requires the use of generators developing a high electromotive force.

Joseph Henry became a member of the American Philosophical Society in 1835, although it was ten years earlier than this that he began his electrical researches at the Albany Academy. Oersted,

in 1819,* had observed the tendency of a magnetic needle to place itself perpendicular to a wire conveying an electrical current. Ampère† had studied the mutual action of currents upon each other, and had thus created the science of electrodynamics. Schweigger had multiplied the number of convolutions of the wire about the needle, increasing proportionately in this way the effect.‡ Arago had succeeded in producing magnetism from an electrical current by winding the wire carrying this current in a loose helix and placing pieces of iron wire in the axis of this helix; thus creating the "electromagnet."§ Sturgeon had further developed this idea by coating the iron bar, which was bent into a horseshoe form, with a non-conducting substance, and winding the wire directly on the bar, thus increasing the closeness of the contact.|| Henry's first paper in electric science was a communication made to the Albany Institute, October 10, 1827, "On Some Modifications of the Electromagnetic Apparatus."¶ In this paper he suggested several improvements in the construction of the electromagnet, which greatly increased its efficiency. In the first place he adopted the multiple arrangement of turns proposed by Schweigger in his galvanometer; and in the second, instead of insulating the bar to be magnetized, he insulated the conducting wire itself, covering the whole surface of the iron with a series of coils in close contact. Sturgeon's electromagnet of 1825 consisted of a stout iron wire bent into a U form, having a copper wire wound loosely round it, forming eighteen turns. Henry's electromagnet of 1829 was made of a piece of round iron about one-quarter of an inch in diameter, bent into the form of a horseshoe, and tightly wound with thirty-five feet of wire covered with silk, forming about four hundred turns. Later in the same year, Henry still further increased the power of his electromagnet, by winding the wire upon the iron core, not in a single strand, but in several; the current flowing simultaneously through the different strands. Using a U-shaped bar of iron, half an inch in diameter and about ten inches long, wound with thirty feet of tolerably fine copper wire, he observed that with a cell containing two and

* *Schweigger, J.*, xxix, 273, 1820; *Gilb. Ann.*, lxvi, 295, 1820.
† *Ann. Chim. Phys.*, xv, 59, 170, 1820; xviii, 88, 313, 1821; xxvi, 390, 1824.
‡ *Allgem. Literaturzeitung*, No. 296, Nov., 1820; *Schweigg., J.*, xxxi, 12, 1826.
§ *Ann. Chim. Phys.*, xv, 93 (1820).
|| *Trans. Soc. Encour. Arts*, xliii, 38 (1825).
¶ *Trans. Albany Institute*, Vol. i, pp. 22, 23 (1827).

a half square inches of zinc surface, this magnet would sustain fourteen pounds. He then wound upon the core a second and similar wire, the ends of which were connected to the same cell; and now the magnet lifted twenty-eight pounds. With a single pair of plates 4 x 6 inches this magnet lifted thirty-nine pounds, or more than fifty times its own weight. This increase of power by multiplying the number of wires without increasing the length of each, as Henry points out, produces its effect in two ways: "first, by conducting a greater quantity of galvanism, and secondly, by giving it a more proper direction."* Thus was constructed what Henry called his "quantity" magnet.

Still larger electromagnets were constructed upon this plan in 1830 and 1831. The former magnet consisted of a bar of soft iron two inches square and twenty inches long, bent into the form of a horseshoe, and weighing twenty-one pounds. Around this was wound five hundred and forty feet of copper wire arranged in nine coils of sixty feet each; each strand being coiled in several layers, and occupying about two inches of the length of the core. The ends of these coils being left separate and numbered, the coils could be combined in any way desired so as to form one continuous coil, or a double coil of half the length, a triple coil one-third the length, etc. When a single pair of coils were put in series the electromagnet lifted sixty pounds; but when the coils were arranged in multiple, forming a double circuit, a lifting power of two hundred pounds was developed. The cell used with this magnet was composed of two concentric cylinders of copper, having a zinc cylinder between them; the exposed zinc surface being about 0.4 square foot, and the acid required about half a pint. With all the coils in parallel the magnet with this battery lifted six hundred and fifty pounds; and with a pair of plates exactly an inch square the magnet lifted eighty-five pounds.†

The 1831 magnet was made for the laboratory of Yale College.‡ The iron horseshoe was about a foot in length, and was made from a bar of octagonal iron three inches in diameter. It was wound with twenty-six strands of copper wire, each about twenty-eight feet

* *Am. Jour. Science and Arts*, xix, 402, Jan., 1831.

† *Am. Jour. Science and Arts*, xix, 404, 405, 1831. See also the excellent memorial address on "The Scientific Work of Joseph Henry," delivered before the Philosophical Society of Washington, Oct. 26, 1878, by Wm. B. Taylor, to which the author would here acknowledge his indebtedness. *Bull. Phil. Soc., Washington*, Vol. ii, p. 230.

‡ *Am. Jour. Science and Arts*, xx, 201, April, 1831.

long. With a single cell of the construction just described, and exposing about five feet of active zinc surface, this magnet lifted twenty-three hundred pounds. It was of this magnet that Sturgeon himself wrote thus: "By dividing about eight hundred feet of conducting wire into twenty-six strands, and forming it into as many separate coils around a bar of soft iron about sixty pounds in weight, and properly bent into a horseshoe form, Prof. Henry has been enabled to produce a magnetic force which completely eclipses every other in the whole annals of magnetism; and no parallel is to be found since the miraculous suspension of the celebrated Oriental impostor in his iron coffin."*

In his "quantity" magnet Henry sought to reduce the resistance to a minimum, and so to obtain a very considerable current even from a very small pair of plates. But he perceived that this was not the whole truth. And in January, 1831, he published a remarkable paper † in which he showed for the first time that a coil composed of several short circuits in parallel, while least effective with a battery of many pairs of plates, was most responsive, on the contrary, to a single voltaic cell; and, on the other hand, that a coil whose parts were all in series, which produced only trifling effects with a single pair, was highly effective with a battery of many pairs. Employing for example a small electromagnet having a core of quarter inch iron wound with about eight feet of copper wire, Henry found that with a single zinc plate, exposing about fifty-six square inches of surface, this magnet lifted four and one-half pounds. On interposing five hundred feet of copper wire between the magnet and the cell it lifted only two ounces; and with one thousand feet interposed only half an ounce. On using a trough battery of twenty-five pairs of plates, on the other hand, the zinc surface exposed being the same as before, the magnet lifted only seven ounces when directly connected. But when the one thousand feet of wire was interposed the magnet sustained eight ounces. In other words, the current from the battery produced a greater magnetic effect after traversing this length of wire than it did without it. He calls an electromagnet having its coil continuous in length an "intensity" magnet; and he says: "In describing the results of my experiments, the terms 'intensity' and 'quantity' magnets were introduced to avoid circumlocution, and

* *Phil. Mag. and Annals of Philosophy*, xi, 199, March, 1832.

† *Am. Jour. Science and Arts*, xix, 400, Jan., 1831.

were intended to be used merely in a technical sense. By the *intensity* magnet I designated a piece of soft iron so surrounded with wire that its magnetic power could be called into operation by an 'intensity' battery, and by a *quantity* magnet a piece of iron so surrounded by a number of separate coils that its magnetism could be fully developed by a 'quantity' battery."* Clearly, therefore, we owe to Henry the credit of having first worked out practically the functions of two entirely different kinds of electro-magnets; one having several separate coils of no great length, designated as a "quantity" magnet, the other provided with a continuous coil of very considerable length, designated as an "intensity" magnet. "The latter and feebler system (requiring for its action a battery of numerous elements) was shown to have the singular capability (never before suspected or imagined) of subtle excitation from a distant source. Here for the first time is experimentally established the important principle that there must be a proportion between the aggregate internal resistance of the battery and the whole external resistance of the conjunctive wire or conducting circuit; with the very important practical consequence that by combining with an 'intensity' magnet of a single extended fine coil an 'intensity' battery of many small pairs, its electro-motive force enables a very long conductor to be employed without diminution of the effect. This was a very important though unconscious experimental confirmation of the mathematical theory of Ohm, embodied in his formula expressing the relation between electric flow and electric resistance, which, though propounded two or three years previously, failed for a long time to attract any attention from the scientific world."†

The practical outcome of these experiments was a most important one. Although Ampère, at the suggestion of Laplace, had examined the question and had shown the possibility of making a telegraph by deflecting a needle through a long length of conducting wire, yet further experiments by Barlow proved that lengthening the conducting wire did actually produce a diminution of the effect. Even with only two hundred feet of wire he found such a sensible diminution as to convince him of the impracticability of the scheme. From Henry's experiment just described, however, "it appears that

* *Smithsonian Report* for 1857, p. 103.

† W. B. Taylor's address, Memorial of Joseph Henry, published by order of Congress, Washington, 1880, p. 227.

the current from a galvanic trough is capable of producing greater magnetic effect on soft iron after traversing more than one-fifth of a mile of intervening wire than when it passes only through the wire surrounding the magnet." In speculating on a result apparently so paradoxical, Henry suggests that the "current from a trough possesses more 'projectile' force (to use Prof. Hare's expression) and approximates somewhat in 'intensity' to the electricity from the common machine." "But be this as it may," he concludes, "the fact that the magnetic action of a current from a *trough* is at least not sensibly diminished by passing through a long wire is directly applicable to Mr. Barlow's project of forming an electromagnetic telegraph; and it is also of material consequence in the construction of the galvanic coil. From these experiments it is evident that in forming the coil we may either use one very long wire or several shorter ones, as the circumstances may require; in the first case, our galvanic combination must consist of a number of plates so as to give 'projectile' force; in the second, it must be formed of a single pair." *

In 1832, Henry described the production of electrical effects from the action of magnets.† Having wound upon the middle of the soft iron armature of his large electromagnet an insulated copper wire about thirty feet long, he observed that whenever the magnet was charged by the battery current a deflection of about 30° to the west took place on a galvanometer connected with the ends of this wire. This deflection was but momentary, however, the needle returning to zero, although the magnet remained excited. On opening the circuit, a momentary deflection to the east took place. "From the foregoing facts," he says, "it appears that a current of electricity is produced for an instant in a helix of copper wire surrounding a piece of soft iron whenever magnetism is induced in the iron, and a current in an opposite direction when the magnetic action ceases; also that an instantaneous current in one or the other direction accompanies every change in the magnetic intensity of the iron."

It was while engaged in these experiments that Henry observed the phenomena due to the induction of one portion of the wire upon another, now called "self-induction." He says: "When a small battery is moderately excited by diluted acid, and its poles

* *Amer. Jour. Science and Arts*, xix, 403, 404, Jan., 1831.

† *Amer. Jour. Science and Arts*, xxii, 403, July, 1832.

(which should be terminated by cups of mercury) are connected by a copper wire not more than a foot in length, no spark is perceived when the connection is either formed or broken; but if a wire thirty or forty feet long be used (instead of the short wire) though no spark will be perceptible when the connection is made, yet when it is broken by drawing one end of the wire from its cup of mercury, a vivid spark is produced." "The effect appears somewhat increased by coiling the wire into a helix; it seems also to depend in some measure on the length and thickness of the wire. I can account for these phenomena only by supposing the long wire to become charged with electricity which by its reaction on itself projects a spark when the connection is broken."*

In 1875, at the meeting of the National Academy in Philadelphia, I showed to Professor Henry the large electromagnet then recently acquired by the University of Pennsylvania. I asked him to place one of his hands upon one of the magnet-terminals, and then, holding the conductor in the other, to break the circuit. He did so, and, naturally, received a decided shock. He looked at me rather reproachfully, as I thought, for the advantage I had taken of him. "Pardon me, Professor Henry," I said, "but I desired to introduce to you one of your own children. He was a little fellow when you knew him and was quite unable to assert himself. But now he has grown to man's estate and is capable, as you see, of dealing a pretty vigorous blow." With a genial smile, he granted me complete absolution.

One of the most important of Henry's investigations, made after he removed to Princeton, was his research on successive induction, an account of which was published in the *Proceedings of the Amer. Philos. Soc.* for November, 1838. In this research he employed five annular spools of different sizes of fine wire (about one-fiftieth of an inch thick) varying from one-fifth of a mile to nearly a mile in length (which might be called intensity helices); and six flat spiral coils of copper ribbon, varying from three-quarters of an inch to one inch and a half in width and from sixty to ninety-three feet in length (which might be called "quantity" coils). "With the single larger ribbon coil in connection with the battery, and another ribbon coil placed over it, resting on an interposed glass plate, at every interruption of the primary circuit an induction spark was obtained at the rubbed ends of the second coil, though

* *Amer. Jour. Science and Arts*, xxii, 408, July, 1832.

the shock was feeble. With a double wire spool (one within the other) of 2650 yards, placed above the primary coil (having about the same weight as the copper ribbon), the magnetizing effects disappeared, the sparks were much smaller, 'but the shock was almost too intense to be received with impunity.'" * Evidently, the induced secondary in this case was a current of great "intensity" and of proportionately small "quantity." Hence these experiments showed that it is possible to induce an intensity current from one of quantity and a quantity current from one of intensity, a principle underlying our modern induction coils and transformers.

Further, Henry used the secondary induced current as an initial current, and so induced from it a tertiary current. "By connecting the secondary coil with another at some distance from the primary, so as not to be influenced by it directly, but forming, with the secondary, a single closed circuit, not only was the distant coil capable of producing, in an insulated wire helix placed over it, a distinct current of induction at the interruption of the primary, but sensible shocks were obtained from it." "By a similar but more extended arrangement, shocks were received from currents of a fourth and a fifth order; and, with a more powerful primary current and additional coils, a still greater number of successive inductions might be obtained." "It was found that, with the small battery, a shock could be given from the current of the third order to twenty-five persons joining hands; also shocks perceptible in the arms were obtained from a current of the fifth order." † As Henry, himself, remarks, "The induction of currents of different orders of sufficient intensity to give shocks could scarcely have been anticipated from our previous knowledge of the subject." By ingeniously introducing a small magnetizing helix into each circuit, Henry found that the direction of these successive currents was alternately reversed with reference to each other.

It was while endeavoring to repeat these successive inductions by means of ordinary electricity that Henry was led to one of his most important discoveries. His apparatus consisted of an open glass cylinder, about six inches in diameter, provided with two long narrow strips of tin foil pasted around it in corresponding heliacal courses, one of these strips being on the outside and the other on the inside, directly opposite to the first. The extremities of the inner

* *Memorial of Professor Henry*, p. 247.

† *Trans. Amer. Philos. Soc.*, Vol. vi (N. S.), p. 303, 1838.

strip were connected to a small magnetizing helix, while the ends of the outer strip were arranged so that the discharge of a half-gallon Leyden jar could be passed through the strip. The magnetization of a needle in the helix indicated an induced current through the inner tin-foil ribbon, and the direction of this magnetization showed the direction of this current. By means of a second and a third cylinder, provided with heliacal tin-foil ribbons, Henry was able to show the production of induced currents of the third and even of the fourth order.

While the results in general were quite similar to those obtained with the voltaic current, a puzzling difference was observed with reference to the direction of the currents of the different orders, as shown by the magnetized needles. "These currents," he says, "in the experiments with the glass cylinders, instead of exhibiting the alternations of the galvanic currents, were all in the same direction as the discharge from the jar; or, in other words, they were all plus." By suitably varying the experiments, the direction of the induced currents was found to depend notably on the distance between the conductors, the induction ceasing at a certain distance (depending upon the amount of the charge and the character of the conductors), and the direction of the induced current beyond this critical distance being contrary to that of the primary current. "With a battery of eight half-gallon jars," he says, "and parallel wires about ten feet long, the change in direction did not take place at a less distance than from twelve to fifteen inches, and, with a still larger battery and longer conductors, no change was found, although the induction was produced at the distance of several feet." Using Dr. Hare's battery of thirty-two one-gallon jars and a copper wire about one-tenth of an inch thick and eighty feet long, stretched across the lecture room and back on either side towards the battery, a second wire stretched parallel with the former for about thirty-five feet and extended to form an independent circuit (its ends connected with a small magnetizing helix) was tested at varying distances, beginning with a few inches until they were twelve feet apart; at which distance the induction in this parallel wire, though enfeebled, still indicated, by its magnetizing power, a direction corresponding with the primary current.*

Continuing his researches in this direction, Henry presented a paper to the American Philosophical Society, in June, 1842, giving

* *Trans. Amer. Philos. Soc.*, vi (N. S.), Art. ix, p. 303, 1838.

an account of these anomalies in electrical induction and the results of his investigation of them. While, with the larger needles subjected to the magnetizing helix, the polarity was always conformable to the direction of the discharge, he found that when very fine needles were employed an increase in the force of the electricity produced changes of polarity. In these researches not less than a thousand needles were magnetized in the testing helices. This perplexing phenomenon was finally cleared up by the important discovery that an electrical equilibrium was not instantaneously effected by the spark, but that it was attained only after several oscillations of the flow.

In a recent lecture before the Royal Institution of Great Britain, Dr. Oliver Lodge says, in speaking of the oscillatory character of a Leyden jar discharge: * "It was first clearly realized and distinctly stated by that excellent experimentalist, Joseph Henry, of Washington, a man not wholly unlike Faraday in his mode of work, though doubtless possessing to a less degree that astonishing insight into intricate and obscure phenomena; wanting also in Faraday's circumstantial advantages. This great man arrived at a conviction that the Leyden jar discharge was oscillatory by studying the singular phenomena attending the magnetization of steel needles by a Leyden jar discharge, first observed in 1824 by Savary. Fine needles when taken out of the magnetizing helices were found to be not always magnetized in the right direction, and the subject is referred to in German works as 'anomalous magnetization.' It is not the magnetization which is anomalous, but the currents which have no simple direction; and we find in a memoir published by Henry in 1842 the following words:

"'This anomaly, which has remained so long unexplained, and which at first sight appears at variance with all our theoretical ideas of the connection of electricity and magnetism, was, after considerable study, satisfactorily referred by the author to an action of the discharge of the Leyden jar which had never before been recognized. The discharge, whatever may be its nature, is not correctly represented (employing for simplicity the theory of Franklin) by the single transfer of an imponderable fluid from one side of the jar to the other; the phenomenon requires us to admit the existence of a principal discharge in one direction and then several reflex actions backwards and forwards, each more feeble than the preceding, until

* *Modern Views of Electricity*, p. 369, London and New York, 1889.

the equilibrium is obtained. All the facts are shown to be in accordance with this hypothesis, and a ready explanation is afforded by it of a number of phenomena which are to be found in the older works on electricity, but which have until this time remained unexplained.' " *

Dr. Lodge continues: "If this were an isolated passage it might be nothing more than a lucky guess. But it is not. The conclusion is one at which he arrives after a laborious repetition and serious study of the facts, and he keeps the idea constantly before him when once grasped and uses it in all the rest of his researches on the subject. The facts studied by Henry do, in my opinion, support his conclusion, and if I am right in this, it follows that he is the original discoverer of the oscillatory character of a spark, although he does not attempt to state its theory. That was first done, and completely done, in 1853, by Sir William Thomson; and the progress of experiment by Feddersen, Helmholtz, Schiller and others has done nothing but substantiate it." †

These investigations of Henry established the fact that "in every case of the electrostatic discharge the testing needles were really subjected to an oscillating alternation of currents and consequently to successive partial demagnetizations and remagnetizations." He at once made use of this singular reflux of current to explain the apparent change in the inductive action caused by distance. If "the primitive discharge wave be in excess of the magnetic capacity of the needle in a given position, the return wave might be just sufficient to completely reverse its polarity and the diminished succeeding wave insufficient to restore it to its former condition; while at a greater distance the primitive wave might be so far reduced as to just magnetize the needle fully, and the second wave, being still more enfeebled, would only partially demagnetize it, leaving still a portion of the original polarity; and so for the following diminished oscillations." ‡

"One more extract I must make from that same memoir by Henry," says Dr. Lodge, "and it is a most interesting one; it shows how near he was or might have been to obtaining some of the results of Hertz; though, if he had obtained them, neither he nor any other experimentalist could possibly have divined their real significance.

* *Proceedings Amer. Philos. Soc.*, Vol. ii, p. 193, June 17, 1842.

† *Modern Views of Electricity*, p. 370, London and New York, 1889.

‡ W. B. Taylor, *loc. cit.*, p. 255.

It is, after all, the genius of Maxwell and of a few other great theoretical physicists, whose names are on every one's lips, which endows the simple induction experiments of Hertz and others with such stupendous importance. Here is the quotation:

"'In extending the researches relative to this part of the investigations, a remarkable result was obtained in regard to the distance at which induction effects are produced by a very small quantity of electricity; a single spark from the prime conductor of a machine of about an inch long, thrown on to the end of a circuit of wire in an upper room, produced an induction sufficiently powerful to magnetize needles in a parallel circuit of iron placed in the cellar beneath at a perpendicular distance of thirty feet, with two floors and ceilings each fourteen inches thick intervening. The author is disposed to adopt the hypothesis of an electrical *plenum*' [in other words, of an ether], 'and from the foregoing experiment it would appear that a single spark is sufficient to disturb perceptibly the electricity of space throughout at least a cube of 400,000 feet of capacity; and when it is considered that the magnetism of the needle is the result of the difference of two actions, it may be further inferred that the diffusion of motion in this case is almost comparable with that of a spark from flint and steel in the case of light.' Comparable it is indeed," says Lodge, "for we now know it to be the self-same process."

A few months later Henry "succeeded in magnetizing needles by the secondary current in a wire more than three hundred feet distant from the wire through which the primary current was passing, excited by a single spark from an electrical machine." * The primary wire used for this purpose was the telegraph line which he had stretched seven years before across the campus of the college grounds in front of Nassau Hall; the secondary or induction wire being suspended in a parallel direction across the grounds in the rear of Nassau Hall, its ends terminating in buried metallic plates. The building itself intervened between the wires.

Moreover, Henry studied induced currents produced by atmospheric electricity. By a very simple arrangement he was enabled to magnetize needles strongly in his study, whenever a lightning flash took place within a radius of twenty miles and when the thunder was scarcely audible. "The inductions from atmospheric dis-

* *Proceedings Amer. Philos. Soc.*, Vol. ii, p. 229, Oct. 21, 1842. Vol. iv, p. 260, June 19, 1846.

charges were found to have the oscillatory character observed with the Leyden jar; and by interposing several magnetizing helices with few and with many convolutions, Henry was enabled to get from a needle in the former the polarity due to the direct current, and in the latter that due to the return current, thus catching the lightning, as it were, upon the rebound." In speaking, subsequently, of the phenomena attending electrical oscillation in discharge, extending as they do to a surprising distance on all sides, Henry remarks: "As these are the results of currents in alternate directions, they must produce in surrounding space a series of plus and minus motions analogous to, if not identical with, undulations;" * a reference to modern theories clearly prophetic. In 1845, he showed that the charge passed along the surface of the wire and not through its whole mass.

As a fitting sequel to the investigations of Hare and of Henry which have now been detailed, and especially to the experiments of the former on "quantity" and "intensity" batteries, taken in connection with those of the latter on "quantity" and "intensity" magnets, it is interesting to notice the experiments upon the electromagnetic telegraph which were subsequently made by two other members of the American Philosophical Society, John William Draper (elected in 1844) and Samuel Finley Breese Morse (elected in 1848). The story is told by Professor Draper himself, in an address delivered, in 1853, to the alumni of the University of the City of New York. He says: "Fourteen years ago, there stood upon the floor of the chemical laboratory of our University a pair of old-fashioned galvanic batteries. Like the cradle of a baby, they worked upon rockers, so that the acid might be turned on or off. A gray-haired gentleman had been using them for many years to see whether he could produce enough magnetism in a piece of iron, at a distance, to move a pencil and make marks upon paper. He had contrived a brass instrument that had keys something like a piano in miniature, only there was engraven on each a letter of the alphabet. When these were touched, the influence of the batteries was sent through a copper wire and a mark answering to a letter was made a long way off. . . . . But, long after the telegraph instruments were perfected, it was doubtful whether intelligence could be sent to any considerable distance. It is one thing to send an electric current

* *Proceedings Amer. Assoc. Adv. Science*, Albany meeting, 1851, p. 89.

a few yards and a totally different affair to send it a thousand miles. Experiments which had been made under the auspices of the Russian government, by Professor Jacobi, of the University of Dorpat, had led to the inference that the law of the conducting power of wires originally discovered in Germany was correct; and, in addition, a corroborative memoir had been read by Lenz before the Imperial Academy of Sciences at St. Petersburg. At this time, so little was known in England as regards this important point, that some of the most eminent natural philosophers connected with universities there embraced the opposite view. I may not be able to make the precise point in dispute clear; it was this: A current passing through a certain length of wire suffers a certain amount of loss. If it should go through a wire a thousand times as long, will the loss be a thousand times as great? The Russians said, yes; the English said, no. If the former was the case, it was universally concluded that the electric telegraph would not be practicable for any considerable distance. A series of experiments was made in the University of New York which established beyond all question the truth of the Russian view. But at that time the higher mathematics were cultivated in our laboratory as well as mere experimenting; and, on submitting the results to such a mathematical discussion, the paradoxical conclusion was brought out that it is a necessary consequence of that law that, after a certain length of wire has been used, the losses become imperceptible. Encouraged by this, a party of gentlemen went with the inventor of the telegraph to a rope-walk, near Bloomingdale, one summer morning and there tested the truth of these conclusions on lengths of wire varying from one to some hundreds of miles. The losses of the currents were measured by the quantity of the gas set free in the decomposition of water. The result was completely successful, and telegraphing for any distance became an established certainty."

Joseph Saxton was elected a member of the American Philosophical Society on October 20, 1837, shortly after his return from London to assume the office of constructor and curator of the standard weighing apparatus of the Philadelphia Mint; a position which had been tendered to him by the Director, Dr. R. M. Patterson. Before going abroad he had made several inventions of note, and, in association with Isaiah Lukens,* had constructed the clock

* Elected to the Amer. Philos. Soc., October 20, 1820.

which still occupies the belfry of Independence Hall. He reached London in 1831 and shortly afterwards became connected with the Adelaide Gallery of Practical Science, having charge of its extensive collection of philosophical apparatus. It was here that he met Telford, Brunel and other eminent English engineers. By them he was introduced to the meetings of the Royal Institution and was admitted into friendly relationship with its Fullerian professor of chemistry, Michael Faraday. The primary facts of magneto-electric and of dynamo-electric induction had already been discovered by Faraday in 1831. Saxton took a great interest in these discoveries and followed them up by constructing the first operative magneto-electric machine. In his appreciative biographical memoir of Mr. Saxton, Professor Henry thus speaks of his great scientific invention:

"It was a part of the general principle discovered by Mr. Faraday that, if an insulated or coated wire were wound with many coils around a cylinder of soft iron, which is suddenly magnetized by touching its ends with a magnet, the same effect would be produced as that described by thrusting in and drawing out a permanent magnet. A current in one direction would be excited in the coil when the core became magnetized, and a current would be produced in an opposite direction the moment the magnetism ceased. Mr. Saxton adopted for the inducing magnet to be employed in his machine a compound one, consisting of a number of steel bars bent into the form of a horseshoe, magnetized separately, and then screwed together so as to form one powerful combination. For the inducing part of the apparatus he bent a cylindrical rod of iron of about three-fourths of an inch in diameter twice at right angles so as to produce the form of a U, the parallel legs of which were at the distance of that of the centres of the two poles of the permanent magnet. Around each of these legs he wound thirty or forty yards of insulated copper wire. Now it is evident from the principle before stated that when the two ends of the legs of this U of soft iron are brought in contact with the poles of the permanent magnet, an instantaneous current will be produced in the natural electricity of the wires, each in a direction opposite to the other. Again, when the soft iron U is drawn suddenly away from the poles of the permanent magnet, a reverse current will take place in each of the coils. But a more intense effect will be produced if the legs of the soft iron horseshoe or U be made to rotate before

the face or poles of the permanent magnet so as to slide off of one on to the other. In this case the effect will be double that of separating it from a single pole; since if, in passing from the first pole it loses its magnetism, in passing on to the second it may be considered as being demagnetized still further, since it is changed into the opposite magnetism. A similar result will be produced with the other leg of the horseshoe. To excite, therefore, the greatest possible amount of electrical induction, Mr. Saxton fastened the U to a revolving axis passing through its crown, to which a rapid rotation could be given by means of a driving wheel and pulley. In order, however, to obtain manifestations of the induced currents produced in the copper wire, the two ends of the coils were so soldered together as to give a single current in one direction through the entire length of the coils. One of the remaining ends was then permanently soldered to a circular disk fastened concentrically to the revolving axis by an insulating collar, with its plane perpendicular to it. This plate dipped into a cup of mercury. The other end of the wire was soldered directly to the revolving shaft or axis. In this arrangement the insulated disk formed one pole of the long wire and the revolving shaft the other; but as they were not connected no electrical excitement was observed when the bobbins were revolved. To make and break the connection at the proper moment, two wires were soldered diametrically opposite each other on a ferule which fitted tightly with friction on the revolving shaft. These wires standing out at right angles to the shaft were cut off at such a length that at each revolution the ends would plunge into the same cup of mercury with the revolving disk, and thus complete and break the circuit twice with each revolution of the bobbins. These wire points were then so adjusted by turning the ferule on the shaft as to cause them to enter and leave the mercury at the moment when the magnetism was increasing or diminishing most rapidly, and consequently when the current had the greatest intensity.

"With this instrument he was able to exhibit a brilliant electrical spark, to decompose water, to show the electrical light between charcoal points, and to give a rapid series of intense shocks. The instrument was exhibited to the public for the first time at the meeting of the British Association at Cambridge, in June, 1833, where it excited much interest. It was permanently placed in the Adelaide Gallery in August of the same year. The poet Coleridge,

who was present at its exhibition in Cambridge, spoke with enthusiasm not only of the magnitude of the discovery of the inductive electrical effects of magnetism—one of the claims of Faraday to imperishable reputation—but also of the ingenious invention of Mr. Saxton by which the transient electrical currents might exhibit their effects in so brilliant and so powerful a manner." *

Notwithstanding the attention which this machine of Saxton's received in scientific circles, no description of it was published until 1836. In October of that year a philosophical instrument maker of London, named Clarke, published a description of a magneto electrical machine practically identical with that of Saxton, and differing only in the fact that the magnet was placed vertically, with the poles downward, instead of horizontally. Not only does he not mention Mr. Saxton by name, nor even allude to his machine, publicly exhibited three years before, but he says with great affectation of originality: "From the time Dr. Faraday first discovered magnetic electricity to the present my attention has been entirely devoted to that important branch of science, more especially to the construction of an efficacious magnetic electrical machine, which after much anxious thought, labor and expense, I now submit to your notice."† Naturally Saxton was prompt to take notice of this disingenuous statement. In the next number of the same journal he says, referring to Clarke's paper: "A reader unacquainted with the progress which magneto-electricity has made since this new path of science was opened by the beautiful and unexpected discoveries of Faraday, might be misled, from the paper I have alluded to, to believe that the electromagnetic machine there represented was the invention of the writer, and that the experiments there mentioned were for the first time made by its means. No conclusion, however, would be more erroneous. The machine which Mr. Clarke calls *his* invention differs from mine only in a slignt variation in the situation of its parts, and is in no respect superior to it. The experiments which he states in such a manner as to insinuate that they are capable of being made only by his machine, have every one been long since performed with my instrument, and Mr. Clarke has had every opportunity of knowing the truth of this statement.

* "Memoir of Joseph Saxton," by Joseph Henry, *Biographical Memoirs Nat. Acad. of Sciences*, Vol. i, pp. 287–317, Washington, 1877.

† *Philosophical Magazine*, III, ix, 262, October, 1836.

"Though my machine is tolerably well known to the public from its constant exhibition at the Adelaide-street Gallery since August, 1833," Saxton continues, "and my claims as its inventor have been acknowledged by Professors Faraday, Daniell and Wheatstone, in papers of theirs published in the *Philosophical Transactions*, yet as no description of it has yet been published I will thank you to insert the following in the ensuing number of the *Philosophical Magazine*."* Then follows an illustrated description of the Saxton machine of 1833.

In this article he says: "The first electromagnetic machine, that is, an instrument by which a continuous and rapid succession of sparks could be obtained from a magnet, was invented by M. Hypolite Pixii, of Paris, and was first made public at the meeting of the Academie des Sciences on September 3, 1832. . . . . It differs from mine principally in two respects: first in M. Pixii's instrument the magnet itself revolves and not the armature; and secondly, the interruptions instead of being produced by the revolution of points, were made by bringing one of the ends of the wire over a cup of mercury, and depending on the jerks given to the instrument by its rotation for making and breaking the contact with the mercury." With regard to the double armature in his machine, Saxton says that he was led to it by the following circumstances: "In November, 1833, Count di Predevalli brought from Paris one of M. Pixii's machines, and it was sent to the Adelaide-street Gallery in order that its effects might be compared with those of mine. Mine was found to excel in the brilliancy of the spark, while M. Pixii's machine was more effective in giving the shock and affecting the electrometer. M. Pixii's machine had a larger keeper and a much greater extent of copper wire. Shortly after Mr. Newman, of Regent street, made a smaller instrument on my construction, which gave the shock more powerfully than my large one did; this also had a greater length of coil, but the effect was at that time partly attributed to the better insulation of the wire. I then convinced myself by some experiments that the increased shock solely depended on the length of the wire. The cause of the difference of effect in the two cases admitted no longer of dispute after the publication of the experiments of Dr. Henry, of Philadelphia, of Mr. Jennings and of Dr. Faraday; as their investigations fully proved that the spark is best

* *Phil. Mag.*, III, ix, 360, November, 1836.

obtained from a magneto-electric coil when short, and the shock when it is long."

Many other ingenious instruments were constructed by Saxton while he was connected with the Adelaide Gallery. He made the apparatus with which Wheatstone's celebrated experiment of measuring the speed of electric transfer through a wire was performed, by which was established the fact that this transfer requires time for its accomplishment. He constructed for the Gallery a compound steel magnet which sustained the weight of five hundred and twenty-five pounds; and also a magnetic needle several feet in length, having a mirror on its end, by which he exhibited for the first time on a magnificent scale the daily and hourly variations of the magnetic force of the earth by the movements of a reflected beam of light. This use of the mirror, however, he had made use of as early as 1825, thus anticipating the similar application made by Ganss. One modification of the revolving mirror thus early used by Saxton consisted in fastening a small mirror to a rotating axis obliquely, so that when a beam of light was thrown upon the mirror, and sufficient speed given to it, a large circle of light would be projected on the ceiling. When, by a powerful train of wheel work, very rapid rotation was produced, any fluctuations taking place in the intensity of the light could at once be detected. He showed, for example, that when the light came from charcoal points forming the poles of a voltaic battery, the circle of light exhibited a mottled or dotted appearance, indicating a rapid alternation of intensity in the electrical discharge.

In a diary kept by him during his residence in London, he gives "a method of determining the position of the interior magnetic poles of the earth by projecting, in the form of a large circle, a section of the earth through the magnetic meridian. On the circumference of this drawing he next projected the dip of the needle in different latitudes from the equator to the pole, and by prolonging these projections until they meet in the interior of the earth, determining the positions of the centres of magnetic influence in the two hemispheres. By this process he arrived at the conclusion that the magnetic polarity of the earth is deeply seated in the interior, and that consequently the magnetism of the globe may be represented by a comparatively short magnet, the axis of which passes through the centre of the globe." Moreover, he made "a drawing of an arrangement of apparatus for obtaining an electrical

spark from the magnetism of the earth. This consists in the rapid revolution of a large bar of soft iron on a horizontal axis at right angles to its length, in the plane of the meridian, the bar being surrounded with a very long wire insulated with a covering of silk, an arrangement being made to break the circuit at the instant of the bar receiving the greatest amount of magnetic induction. He succeeded, by this arrangement, in producing currents of electricity of considerable power, but for the want at the time of a sufficient length of insulated wire, he was unable to increase the intensity sufficiently to produce the spark." *

Although Saxton's preëminent ability as a mechanician had secured for him the tender of the office of director of the printing machinery of the Bank of England, he preferred to return to the United States and to accept the office of constructor and curator of the standard weighing apparatus of the Philadelphia Mint. During his connection with the Mint he constructed "the large standard balances still used in the annual inspection of the assays and the verification of the standard weights for all the Government assay and coining offices in the United States. The knife edges of these implements are of the hardest steel, turning upon plates of agate; and such sensibility has the apparatus that when loaded with fifty pounds it turns with one-tenth of a grain; or, in other words, with the three-millionth part of its load."

Already, in 1834, he had been awarded the John Scott medal of the Franklin Institute for a reflecting pyrometer, in which he had utilized the mirror method of observation to determine the temperature by means of the linear expansion of a metallic rod when under the influence of heat. In 1843, upon his appointment by Professor A. D. Bache to the office of Superintendent of Weights and Measures, he applied this mirror method to the construction of the standard bars used by the Coast Survey in such a way as to secure an unvariable length in the bar when subjected to different temperatures. This was done so successfully that the different measurements of a base line five miles in length did not differ by more than half an inch.

In 1858, Saxton presented to the American Association for the Advancement of Science, at its Baltimore meeting, a paper giving an account of the principal applications which he had made of the

* Henry's Biographical Memoir, *loc. cit.*, p. 303.

revolving mirror to minute measurements. In applying this principle to the adjustment of the measuring rods of the Coast Survey, as well as for certain other minute measurements, he had made use of a graduated scale instead of a beam of light, the reflected image of which, considerably magnified, was observed by means of a telescope. With this improvement, an elongation which does not exceed the one hundred thousandth part of an inch becomes a very distinct and measurable magnitude. The same apparatus was applied, at the request of General Meigs, to determine the expansion of different specimens of marble cut into prisms of the same length and cross section. The principle involved is evidently applicable in all cases where changes in length, in angle or in position are to be determined. Saxton himself applied it in the Magnetic Observatory of Girard College to indicate changes in the magnetic dip and also to magnify the motion of the axis of an aneroid barometer. For this latter purpose, the case of the instrument is removed and a mirror about one-half an inch square is attached to the first axis of motion. The aneroid is then fastened to a bracket on the wall, the axis carrying the mirror being placed horizontally. At a distance of about fifteen feet from the mirror a telescope is permanently adjusted, so that the image of a divided scale placed immediately below the object glass can be seen in the mirror. With this arrangement, the slightest change in the pressure of the air becomes apparent. The opening or closing of a door, or a gust of wind over the house, produces marked disturbances in the pressure of the atmospheric column, the extent of which can be readily measured.*

Besides the representative investigations of Franklin in Electrostatics, of Hare in Electrokinetics, of Henry in Electromagnetics, and of Saxton in Magneto-electrics, which have now been considered, members of the American Philosophical Society have made important researches in Magnetism, and especially in the magnetism of the earth.

David Rittenhouse became a member of the Philosophical Society on the 19th of January, 1768. On the 6th of February, 1781, he read a paper before the Society, entitled "An Account of Some Experiments on Magnetism,"† in which he set forth his theory of the magnetism of iron. In this paper he says: "I sup-

* Henry's Biographical Memoir of Saxton, *loc. cit.*, p. 312.
† *Trans. Amer. Philos. Soc.*, I, ii, 178, 1781.

pose then that magnetical particles of matter are a necessary constituent part of that metal which we call iron, though they are probably but a small proportion of the whole mass. These magnetical particles, I suppose, have each a north and a south pole, and that they retain their polarity however the metal may be fused or otherwise wrought. In a piece of iron which shows no signs of magnetism, these magnetical particles lie irregularly with their poles pointing in all possible directions; they therefore mutually destroy each other's effects. By giving magnetism to a piece of iron we do nothing more than arrange these particles, and when this is done it depends on the temper and situation of the iron whether that arrangement shall continue, that is whether the piece of metal shall remain for a long time magnetical or not. . . . By applying a magnet to a piece of iron," he continues, "it becomes magnetical; for the magnet acting strongly on the above-mentioned particles, that action arranges them properly; overcoming the resistance of the surrounding parts of the iron, and this resistance afterwards serves to secure them in their proper situations and prevents their being deranged by any little accident." Moreover, "iron or soft steel receives magnetism more easily than hardened steel, but will not retain it. May not this be," he suggests, "because the magnetical particles are not so closely confined in soft as in hardened steel, and on that account more easily admit of arrangement or derangement?" In one of his experiments, Rittenhouse took a soft steel ramrod, having no sign of magnetism, and, holding it in the line of the dip, struck it on one end with a hammer. The lower end became a north pole, and when laid on a watch crystal "it traversed very well." "From all this," he reasons, "does it not seem very probable that during the concussion of the stroke and whilst the magnetical particles of the rod were most disengaged from the surrounding matter, the active power above mentioned seized them and arranged them properly, where being confined, the rod afterward remained magnetical." With reference to this "active power," he says in a footnote: "There is some power, whencesoever derived, diffused through every part of space which we have access to, which acts on these magnetical particles, impelling one of their poles in a certain direction with respect to the earth, and the other pole in the opposite direction. The direction in which this power acts I take to be the same with that of the dipping needle."

In his article on "Magnetism," published in the *Encyclopedia Britannica*, Professor Chrystal says: "The notion of molecular magnets seems to have been suggested by Kirwan; but it was not until a definite form was given to it by Weber that it acquired any importance." The views of Kirwan here referred to are contained in a paper entitled "Thoughts on Magnetism," published in the *Transactions of the Royal Irish Academy* for 1797. In this paper Kirwan states as follows: "A magnet therefore is a mass of iron or of iron ore, whose oxygenation does not exceed twenty per cent. or thereabouts, whose particles are arranged in a direction similar to that of the great internal central magnets of the globe. This I call the magnetic arrangement. . . . . Hence a magnet *attracts iron* when within the sphere of its action by forcing, in virtue of its attractive power, a certain proportion of its integrant particles into a disposition and arrangement similar to that of its own. . . . . The disposition of parts in a particular magnet, being similar to that which obtains in the great internal general magnet, extends in the direction of from north to south. Hence magnets, when at liberty to move with a certain degree of freedom, and iron when a sufficient number of its particles are arranged in that direction, and has sufficient liberty to conform to it, points to those poles. Hence this property is called polarity. . . . . The magnetic power is greater or lesser according to the number and homogeneity of the particles *similarly* and *magnetically* arranged. . . . . The power of a magnet (everything else being equal) depends on the *number of its surfaces magnetically arranged* and the *accuracy* of that arrangement. . . . . The arrangement is accurate when the synonymous surfaces are exactly parallel to each other and originally conformed to and parallel with those of the great general magnet. . . . . *Any motion* communicated to the integrant particles of iron placed in a proper situation helps them to assume the magnetic disposition already impressed upon them by the great general magnet."*

These quotations from Kirwan's paper appear to show that the views he held on the nature of magnetism were vague and indefinite; and therefore seem to justify Prof. Chrystal's conclusion that the molecular theory in the form proposed by Kirwan did not acquire any importance. Especially would this be so in view of the fact that in 1600 Gilbert, in his book "*De Magnete*,"

* *Trans. Royal Irish Acad.*, vi, 177, 1797.

showed that if a magnet be broken each piece becomes a complete magnet. The opinions of Rittenhouse, however, seem to be greatly more clear and precise. The idea of "magnetical particles" each having a north and a south pole, and each retaining its polarity, even when the metal is fused, is a perfectly definite one. When a piece of iron shows no magnetism, it is because the particles lie irregularly, and mutually neutralize one another's action; the process of magnetization consisting simply in arranging these particles so that their similar poles face similarly. If now we take into the account the fact that the paper of Rittenhouse antedates that of Kirwan by about sixteen years, it would seem clear that to our fellow-member belongs indisputably the credit of the origin of the molecular theory of magnetism.

Alexander Dallas Bache was elected a member of the American Philosophical Society, April 17, 1829; only a few months after he had taken up his residence in Philadelphia as Professor of Natural Philosophy and Chemistry in the University of Pennsylvania. His attention was early directed to the subject of Terrestrial Magnetism by the remarkable investigations in this direction made by Gauss and Weber. And, in 1830, he erected and equipped a little magnetic observatory in the garden attached to his residence, in which observations were made regularly for a period of four or five years. It was in this observatory that, aided by his wife and by his pupil, John F. Frazer, he determined with accuracy, for the first time in this country, the periods of the daily variations of the magnetic needle. Here, also, by another series of observations, he determined the connection of the fitful variations of the direction of the magnetic force with the appearance of the aurora borealis. His first memoir on the subject was presented to the American Philosophical Society in November, 1832, and contains the results of hourly observations on the declination.* These observations were made with a very long needle provided with a graduated arc at each end. Terrestrial magnetism soon became with him a favorite subject and one to which he continued to make valuable contributions at intervals during his whole life. Even in his journeys he carried with him portable instruments with which he determined the magnetic constants of the points he visited. "What he accomplished in later years for this favorite branch of science," says Dr. Gould,

* "On the Diurnal Variation of the Magnetic Needle," *Trans. Amer. Philos. Soc.* (New Series), Vol. v, p. 1.

"the world knows; and it is certainly not too much to say that, of what we know to-day of the distribution, intensity and periodic and secular changes of terrestrial magnetism, we are indebted quite as much to Bache as to any other one man."

In connection with his colleague, Courtenay, then Professor of Mathematics in the University of Pennsylvania, he undertook an elaborate investigation of the value of the dip and the horizontal intensity of the earth's magnetism at several places in the United States, the results of which were published in two extended memoirs printed in the *Transactions* of the Society.*

On his thirtieth birthday, July 19, 1836, Bache was elected President of Girard College, then about to be put into operation under the provisions of the will of Stephen Girard; and, receiving instructions to visit Europe in order to examine similar institutions there, he resigned his chair in the University and spent two years abroad. While in Europe he found opportunity to determine the magnetic dip and horizontal intensity at twenty-one stations, with the same apparatus and by the same methods which he had employed in America; the results of which determinations he communicated to the Society in a paper entitled, "Observations of the Magnetic Intensity at Twenty-one Stations in Europe." † These observations were made with the view of ascertaining the relative direction and strength of the magnetic force in Europe and America by the comparison of parallel series of observations in the two countries with the same instruments. They also served, in most instances, to settle with greater precision than had previously been attained the relative magnetic condition of the stations at which they were made.

It was while waiting for the College to go into operation that Prof. Bache entered into active coöperation with the great undertaking of the British Association, "to determine, by contemporaneous observations at widely separated points, the fluctuations of the magnetic and meteorological elements of the globe. This coöper-

* "Observations to Determine the Magnetic Dip at Baltimore, Philadelphia, New York, West Point, Providence, Springfield and Albany," *Trans. Amer. Philos. Soc.* (New Series), v, 209, 1834.

"On the Relative Horizontal Intensities of Terrestrial Magnetism at Several Places in the United States, with the Investigation of Corrections for Temperature and Comparisons of the Methods of Oscillation in Full and Rarefied Air," *Trans. Amer. Philos. Soc.* (New Series), v, 427, 1836.

† *Trans. Amer. Philos. Soc.* (New Series), vii, 75, 1840; *Proceedings Amer. Philos. Soc.*, i, 185.

ation, in which, no doubt, a feeling of national pride mingled itself with his ardor for the advancement of science, consisted primarily in the establishment of an observatory, to which the trustees of Girard College contributed a full set of instruments, combining all the latest improvements, and which was supported by the American Philosophical Society and by a number of liberal and intelligent individuals. The observations which were here continued at short intervals, both by day and night, for five years, form a rich mine of statistics from which, until within the last few years of his life, the professor drew a highly interesting series of results without exhausting the material." * Of this Girard College Magnetic Observatory, in which, by the untiring labors of Professor Bache himself and his efficient assistants, this great wealth of valuable scientific material was gathered, no vestige remains. Not only is there no trace of the building itself or any of its parts to be found within the walls of that institution, but there is even a considerable difference of opinion as to its exact location. No single spot in Philadelphia surpasses this in scientific interest. May we not hope that the trustees of Girard College will see to it that the exact site of this observatory is accurately determined and that at least a tablet be placed thereon to mark a spot so important as a magnetic centre? †

In November, 1843, Professor Bache was appointed Superintendent of the Coast Survey of the United States; and, a month later, Superintendent of Weights and Measures. "The volume of testimonials and recommendations," says Dr. Gould, "upon the strength of which this appointment was made, has been shown me; and their number and character has made a deep impression. I cannot believe that such a weight of recommendation was ever brought at any time in support of a candidate for office on purely intellectual grounds. I can think of no man in the country, eminent in physical science, or holding a prominent scientific position, whose name was not signed to some one of that voluminous mass of memorials asking the appointment of Professor Bache. All the sci-

* "Biographical Memoir of Alexander Dallas Bache," by Joseph Henry, *Biographical Memoirs Nat. Acad. Sciences*, Vol. i, p. 181 Read April 16, 1869.

† Mr. Charles H. Cramp, of this city, and Mr. George Davidson, of San Francisco, both members of the American Philosophical Society, were assistants to Prof. Bache in this observatory. Mr. Cramp recently gave to the writer an extremely interesting account of the building and of the instruments contained within it, as well as of the methods of observation which were pursued in the determinations.

entific societies and colleges, together with several of the learned associations of Europe, gave their influence and added their endorsement to the request."* It is gratifying to know that his appointment to this position was first suggested by the members of the American Philosophical Society.

Among the many directions in which the operations of the Coast Survey were now to be extended, Professor Bache very naturally included terrestrial magnetism; observations of the dip and the variation of the needle and of the intensity of the earth's magnetism being introduced as a part of the regular routine. He retained his own personal interest in these matters, and contributed from time to time scientific memoirs upon them to the learned bodies of which he was a member.

Of the memoirs thus communicated a few may here be mentioned. At the Albany meeting of the American Association, held in 1856, a paper was presented by Professor Bache, in conjunction with J. E. Hilgard, "On the General Distribution of Terrestrial Magnetism in the United States, from Observations Made in the United States Coast Survey and Others." At that time the number of magnetic stations established by the Survey amounted to one hundred and sixty, distributed, though somewhat irregularly, along the entire sea coast of the United States, on a great portion of which magnetic observations were now made for the first time. The object of the paper was to deduce from the Coast Survey observations, in connection with others of recent date, the general distribution of terrestrial magnetism in the United States, as far as the data available will warrant the conclusions. With regard to the method and instruments used, only a brief notice is given. "In observing the *declination*, the magnetic meridian has generally been obtained by means of collimator magnets, using Gauss and Weber's transportable magnetometer; while the astronomical meridian was derived from the triangle sides of the Coast Survey or obtained by direct observations. The *dip* has been observed with needles of from six to ten inches in length, made by Gambey and by Barrow. Two needles have generally been used, or, when only one was employed, it has been carefully tested and compared. The *horizontal intensity* has been determined in absolute measure by vibrations and deflections, according to the methods of Gauss and Lamont. The units of measure are those used in the British surveys.

* "Address in Commemoration of Alexander Dallas Bache," by Benjamin Apthorp Gould, *Proceedings Amer. Assoc. Adv. Science*, Chicago meeting, 1868, Vol. xvii, p 1.

From the agreement of repeated observations, it is inferred that the uncertainty of the observations at a particular spot does not exceed one or two minutes of arc in the declination and dip and one five-hundredth part of the horizontal force." The results obtained are given in a table, showing, in parallel columns, "the latitude and longitude of the stations, the declination, dip and horizontal intensity of the earth's magnetic force, the date of the observations and a reference to the particular locality, its geology and other attending circumstances." *

At the Springfield meeting in 1859, Professor Bache presented to the American Association a paper entitled "General Account of the Results of the Discussion of the Declinometer Observations made at Girard College, Philadelphia, between the Years 1840 to 1845, with Special reference to the Eleven-Year Period." "In coöperation," he says, "with the scheme adopted at the British colonial observatories, a series of magnetic and meteorological observations were made at the Girard College Observatory with instruments purchased under the direction of the trustees of the College, the observations being made under the patronage of the American Philosophical Society, and finally completed for the use of the Topographical Bureau of the War Department. These observations were made under my direction and superintendence. The series commenced in May, 1840, and, with short interruptions, terminated in June, 1845; thus furnishing a five years' series of magnetic observations taken bi-hourly up to October, 1843, and after that date hourly. . . . . It is proposed especially to investigate the law of the eleven-year period, or, as it is more frequently called, the decennial period, there being yet an uncertainty as to its precise length. It is supposed to have some direct or indirect connection with the solar spot period, which correspondence, according to late investigations by Prof. R. Wolf, is so close as to exhibit even analogous disturbances."† Mr. Schott's mathematical discussion of these observations gave results showing plainly the inequality constituting the ten or eleven-year period, the year 1843 being directly indicated as the year of the minimum range of the diurnal fluctuation.

Two papers dealing with the phenomena of Terrestrial Magnetism were presented by Professor Bache to the American Association at its meeting in Newport in 1860. The first of these was a "Gen-

* *Proc. Amer. Assoc. Adv. Science*, x, 187, 1856.

† *Ibid.*, xiii, 248, 1859.

eral Account of the Results of Part II of the Discussion of the Declinometer Observations, made at the Girard College, Philadelphia, between 1840 and 1845, with Special Reference to the Solar-diurnal Variation and its Annual Inequality." The results of this discussion are thus given: "The general character of the diurnal motion is nearly the same for the summer half year, for the winter half, and therefore for the whole year. The greatest eastern deflection is, at a mean, reached at a quarter before eight A.M., being a quarter of an hour earlier in the summer, and half an hour later in the winter. Near this hour the declination is a minimum. The greatest western deflection is reached, at a mean, at a quarter after one o'clock P.M., a few minutes earlier in both the summer and winter. At this hour the declination is a maximum. The diurnal curve presents but a single wave, slightly interrupted by a deviation occurring during the hours near midnight, or from ten P.M. to one A.M., when the magnet has a direct or westerly motion. Shortly after one A.M. the north end of the magnet moves easterly, completing the cycle and arriving at its eastern elongation shortly before eight A.M. This nocturnal deviation is well marked in winter, vanishes in summer, and is but slightly perceptible in the annual curve."*

The second paper is an "Abstract of a Discussion of the Influence of the Moon on the Declination of the Magnetic Needle, from the Observations made at the Girard College, Philadelphia, between the Years 1840 and 1845." In the previous discussions of the Philadelphia observations of magnetic declination, Professor Bache had shown how the influence of magnetic disturbances, of the eleven-year period, of the solar diurnal variation and its annual inequality, of the secular change and of the annual variation might be severally eliminated, leaving residuals from which the lunar influence is to be studied. "One of the first questions to determine is, how many of these residuals must be used to give a definite result? and another one is whether numbers deduced from different parts of the series would give harmonious results? To test both of these the observations were formed into three groups, one containing four thousand nine hundred in nineteen months of 1840 and 1841; another, six thousand seven hundred and fifteen results in twenty-one months of 1842 and 1843; and a third, ten thousand and twenty-nine

* *Proc. Amer. Assoc. Adv. Science*, xiv, 74, 1860.

results in eighteen months of 1844 and 1845; in all twenty-one thousand six hundred and forty-four results." The curves obtained by discussing these groups "all agree in their distinctive character, and show two east and two west deflections in a lunar day, the maxima W. and E. occurring about the upper and lower culminations, and the minima at the intermediate six hours. The total range hardly reaches 0.5′. These results agree generally with those obtained for Toronto and Prague. From eight thousand to ten thousand observations seem to be required to bring out the results satisfactorily, and the best results are derived from the use of both groups."*

These discussions of the magnetic and meteorological observations made at the Girard College Observatory, were published *in extenso* in the *Smithsonian Contributions to Knowledge*, and also in the *Reports of the Coast Survey*. Besides the three parts above mentioned, nine other parts were issued, the last in 1864; all covering the time from 1840 to 1845, and including only the observations made in that single observatory.

I have now accomplished the task which has been assigned to me by your Committee. I have endeavored to sketch briefly but clearly the progress which has been made in electrical science since this Society was founded, and to present the steps of this progress in the form of epochs, each typified by the work of one of the eminent men of science whose names have shed lustre upon the roll of its membership. The labors of these men have mightily contributed to advance the development of scientific thought throughout the world, and so to bring about that exceptional evolution of electrical facts and theories which is the distinguishing feature of the science of the nineteenth century. Space has not allowed me to recount all that has been done by the members of this Society, even in this single direction. Many of them are still actively pushing outward the boundaries of knowledge, and are laying the foundations of yet more remarkable achievements. The work of these men it will be the privilege of some future historian of the Society to chronicle. May the record of the contributions made by the American Philosophical Society to the progress of science, in the time to come, be as rich and as brilliant as is its record since it first came into existence in 1743.

* *Proc. Amer. Assoc. Adv. Science*, xiv, 83, 1860.

APPENDIX.

List of Papers on Electricity and Magnetism Published by the American Philosophical Society.

I. TRANSACTIONS (OLD SERIES).

II. TRANSACTIONS (NEW SERIES).

III. Proceedings.

Mr. Wharton next addressed the Society as follows:

Gentlemen:—A few years ago it was not known that any other substance but iron possessed the power of acquiring permanent magnetism, though it was of course known that nickel and cobalt were magnetic metals. The fact that they themselves could be made into magnets was never known until I myself, with my own hands, hammered out the first magnetic needle that ever had been made of any other substance than steel, which I think was in the year 1874. I had after a short time several compasses constructed, furnished with needles made of nickel. One of them I sent to the Russian Government, one to the French Government, one to the British Government and one to our own, in order that they might be sent to sea and experimented with. The British Government and the American Government took no notice of it, but the Russian and French Governments investigated the subject very thoroughly and made reports on it. Lord Kelvin, then Sir William Thompson, investigated the properties of sheet nickel, I furnishing him a piece of sheet nickel with which he investigated the properties of

nickel in that form as compared with iron in that form, for the production of galvanic currents. Several years later, in order to increase what is called the magnetic quality of nickel, which you no doubt know is much feebler than that of steel, I had a series of bars made of alloys of nickel and tungsten, as, it being known that tungsten increases the magnetic quality of steel, I thought it might act the same with nickel. With those bars I investigated and found that the hypothesis which I had formed was correct, and I had a series of those made with progressive increases of the alloy of tungsten, and the result of all that has been published and I will not detain you with it. Those series of bars unfortunately were lost, as I sent them to the Exhibition at Paris, and they were never returned. One of the ship's compasses which were magnetized, I think in the year 1874, I lately investigated and found that the magnetism remained apparently about as strong as it was in the beginning, showing that the magnetism of a magnetic needle composed of pure nickel is permanent.

President Fraley then made the following closing address:

The programme for the celebration of our 150th anniversary is now literally completed. I cannot say farewell to you, for what I have felt here in meeting so many new and so many old friends does not permit me to entertain the thought that I must part from them. All I can say is that we have been signally blessed in this celebration. We have not only had a perpetuation of good words and perpetuation of good cheer, but the beginning of friendships which will last certainly so long as we are permitted to tread the earth. I thank you all for what has been given to us upon this occasion, hoping, as Prof. Barker has expressed the hope, that the good work for the promotion of science will go on for a series and series and series of 150 years; that not only our own institution may take its part in the great work of promoting useful knowledge, but all the institutions that are represented here and all others who are not and have tendered their congratulations will equally continue at work, and that those who come, I will say 150 years hence, but I will shorten the period and say all those who may come here fifty years hence, will find the old hall standing on its foundation with accumulated treasures within its walls and precious memories encircling the hearts of all those who have been in the past members

of the Society and who are now its present members, all those who have been correspondents of the Society in the past and are present correspondents, and that it will be followed by a perpetuity of existence and a perpetuity of correspondence that will endure forever.

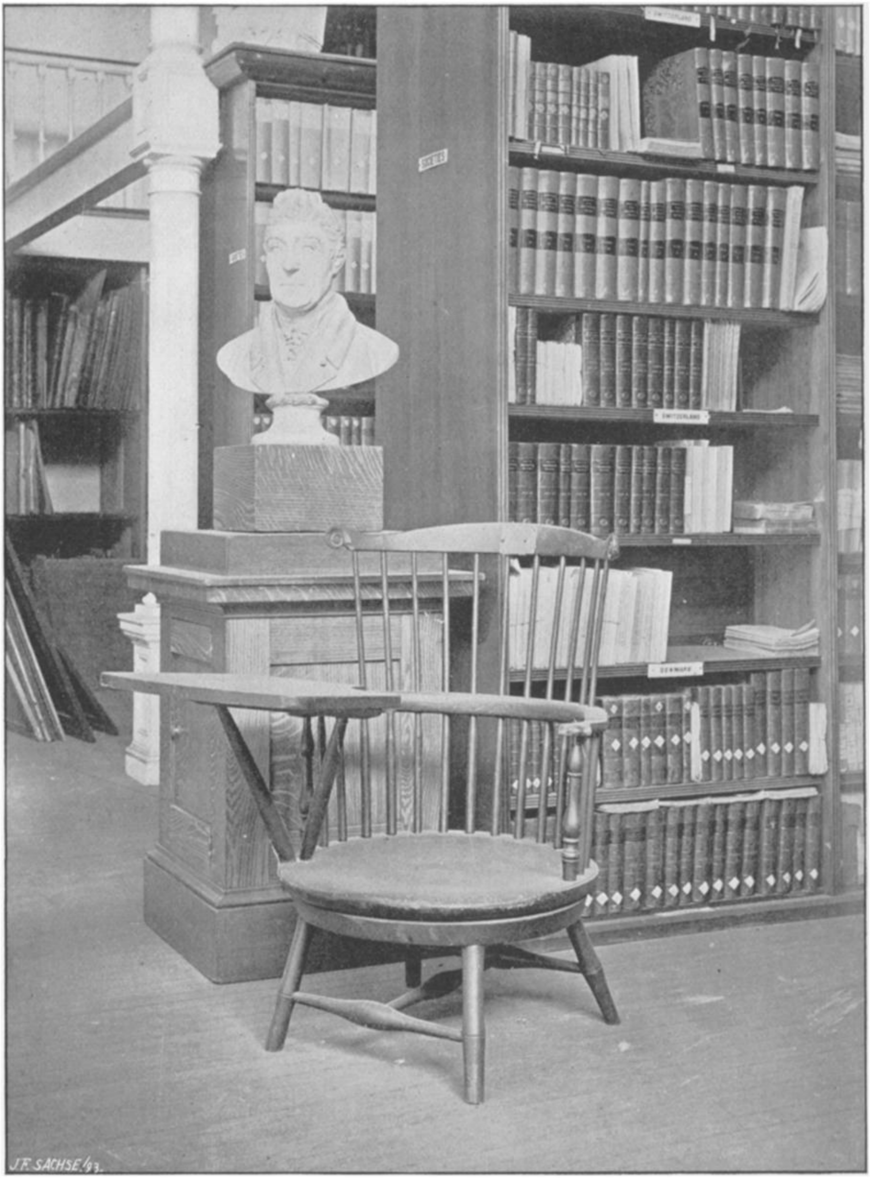
So I shall not say farewell, but I will announce that so far as I am concerned this body shall be continued in session until another fifty years roll around, and ask that you will make the advent of such a coming a welcome to every one.

Adjourned.

Friday, May 26—3 o'clock P.M. Through invitation of Mr. Charles H. Cramp, the Society and guests visited Cramp's ship yard and inspected the plant.

The Union League and the Art Club of Philadelphia opened their Houses for the use of the delegates and members during their stay in the city.

The rooms of the College of Physicians were opened daily for the use of the guests and members of the Society, from 10 A.M to 6 P.M.



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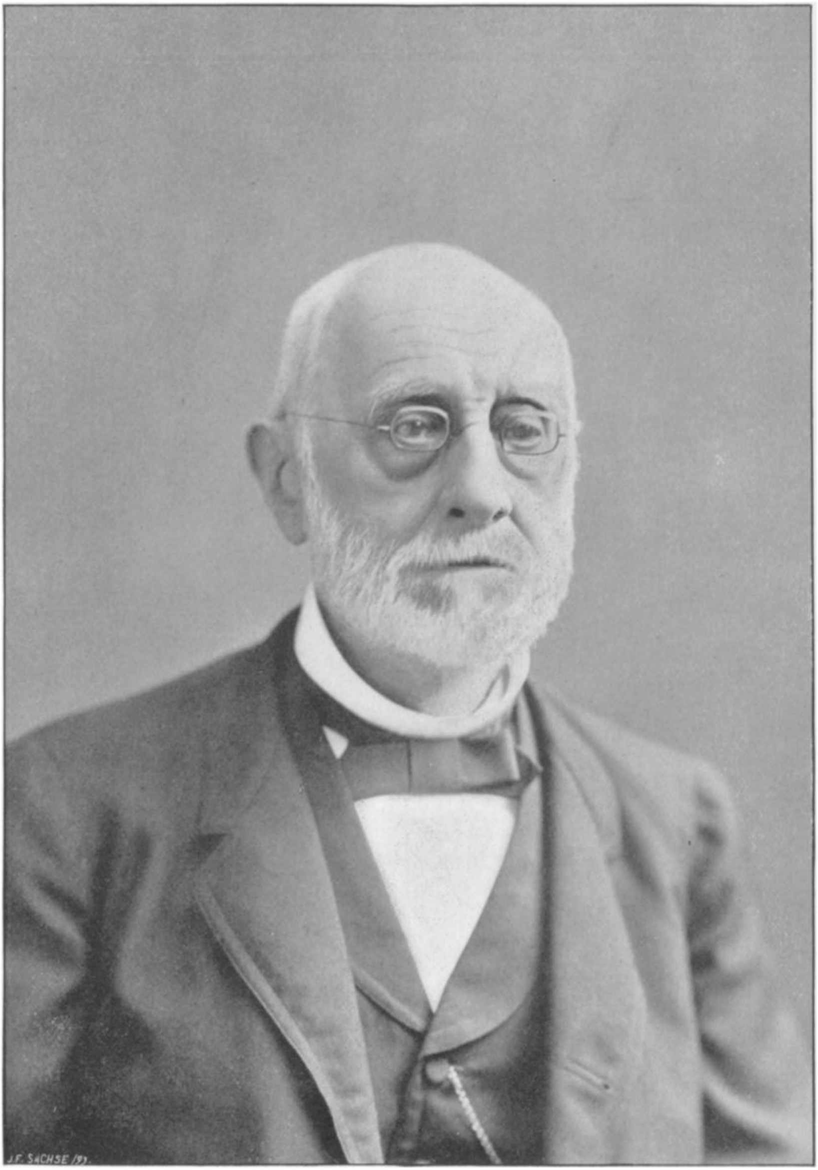
JEFFERSON'S CHAIR IN WHICH HE WROTE THE DECLARATION OF INDEPENDENCE.



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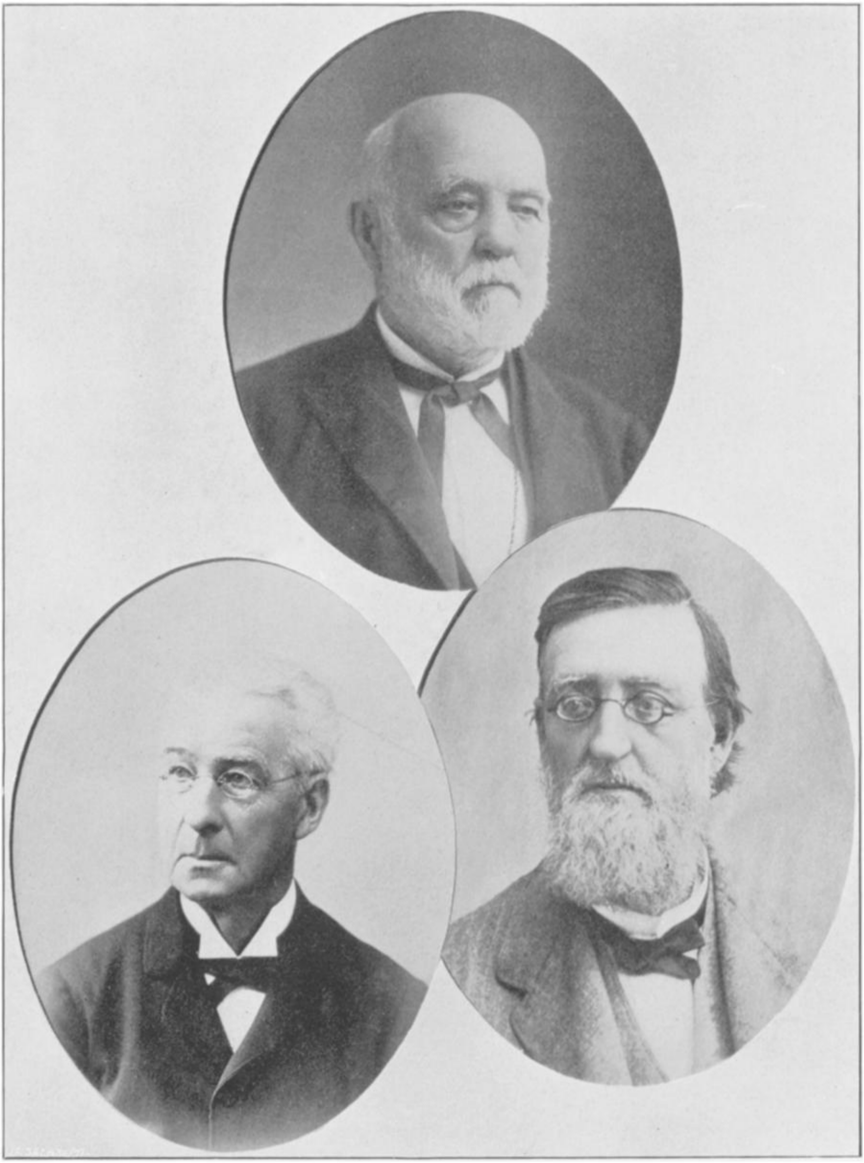
HON. FREDERICK FRALEY, L.L.D.



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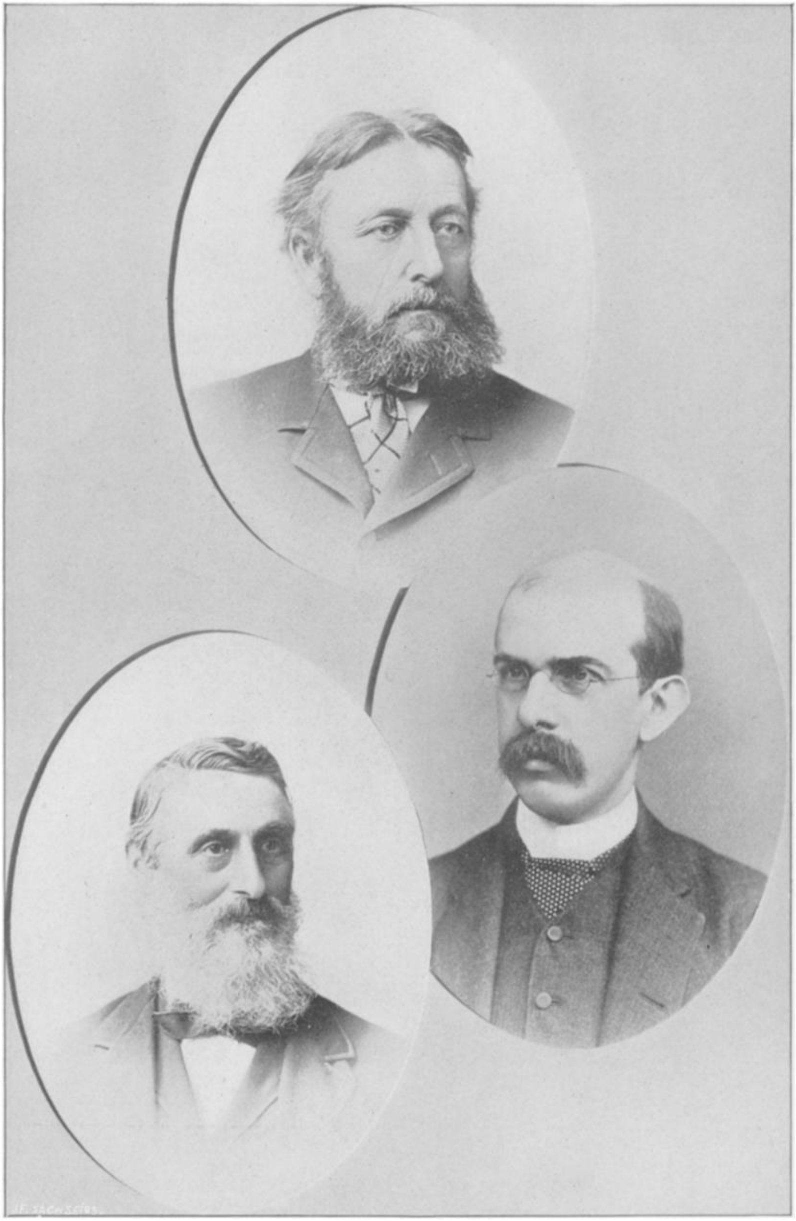

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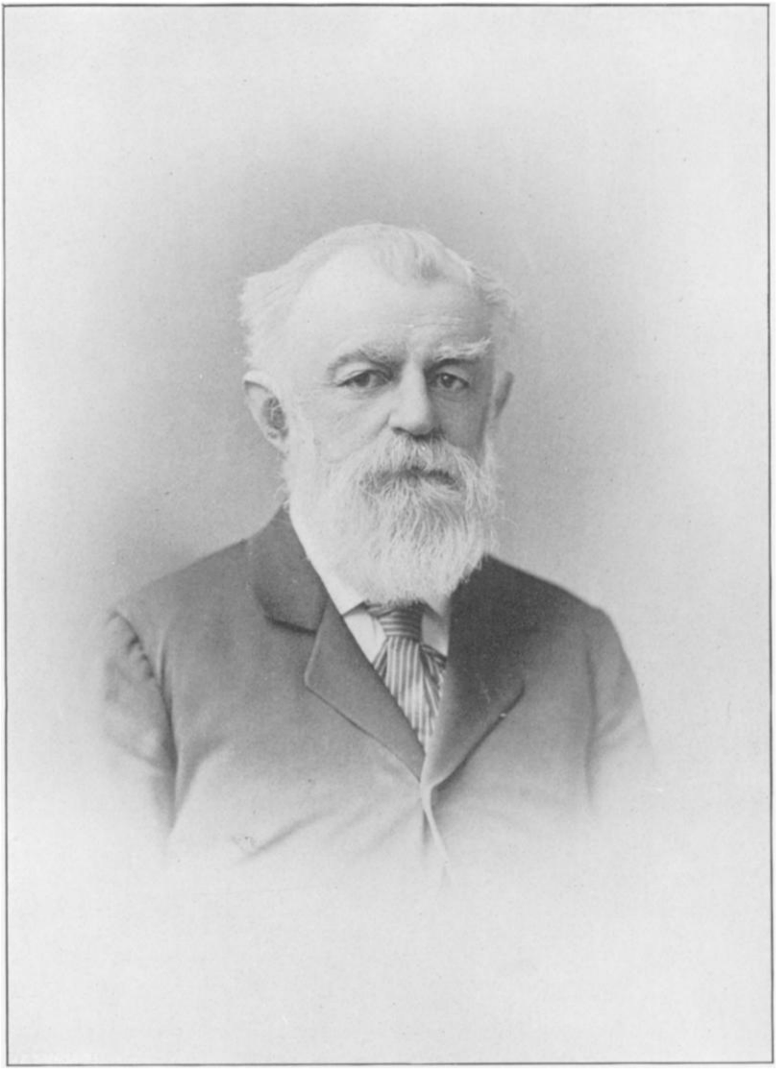

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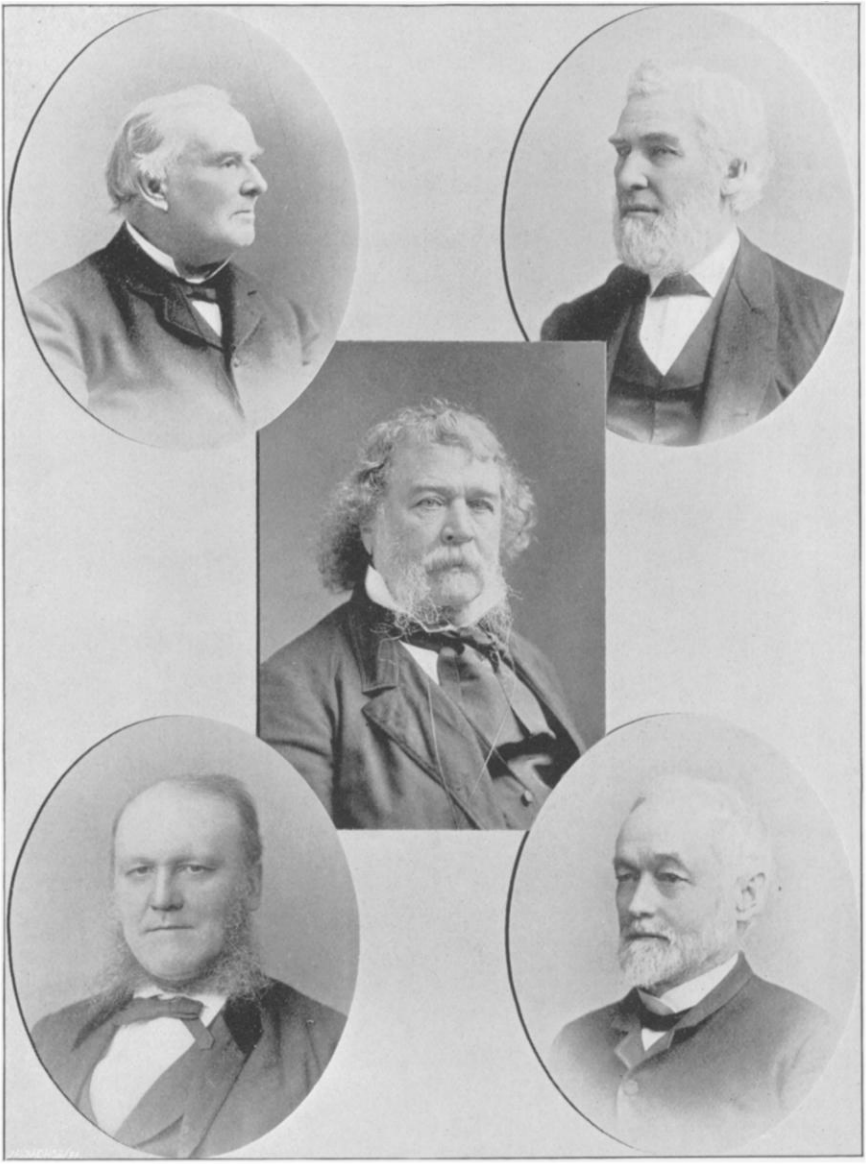

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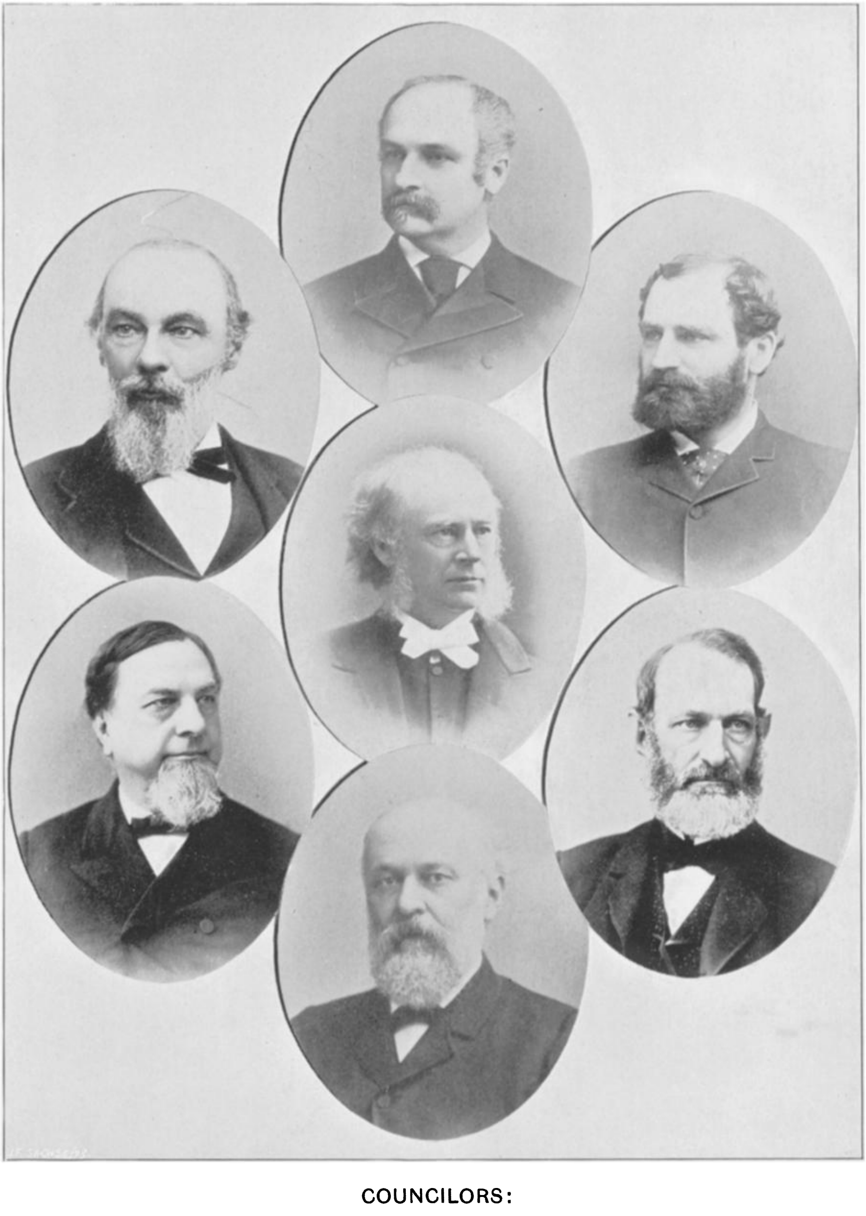

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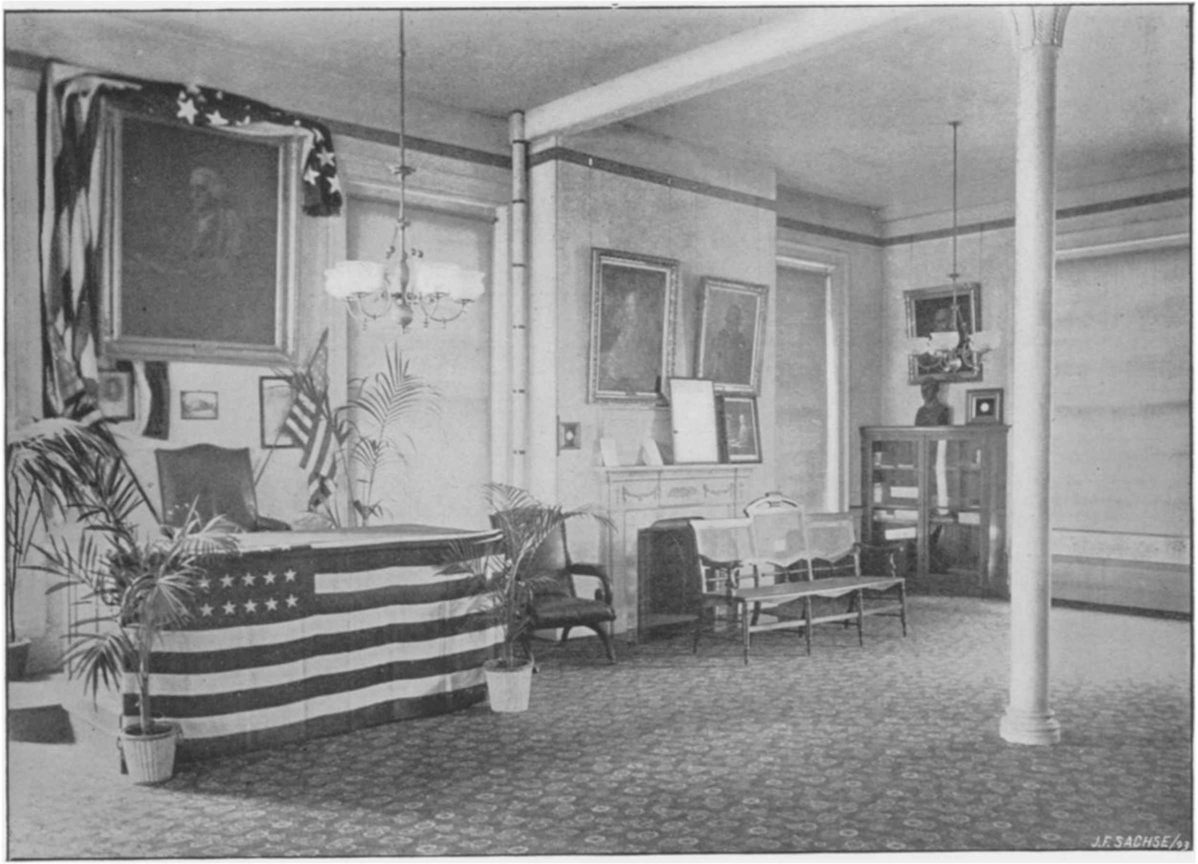

MEETING ROOM, FACING SOUTH.

MAY 22-26, 1893.

ERRATA in the Orientation and Order of the Plates.

PLATES i., iv., viii., ix., xi., xii., xiii.—*North* point at the bottom; *South* at the top; *West* to the left hand; *East* to the right hand. This corresponds to the orientation of the object as viewed in an astronomical telescope.

PLATES v., vi., x.—*North* point at top; *South* at bottom; *East* to the left hand; *West* to the right hand.

PLATE ii.—*For* M 13 Herculis *read* M 15 Pegasi. *North* point is midway between bottom and left hand; *South* midway between top and right hand; *West* between top and left hand; *East* between bottom and right hand.

PLATE iii.—*For* M 15 Pegasi *read* M 13 Herculis. *North* point is at right-hand side; *South* at the left hand; *West* at the bottom; *East* at the top.

PLATE vii.—*North* point is midway between bottom and left-hand side; *South* between top and right hand; *West* between top and left hand; *East* between bottom and right hand.